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Factors affecting implementations of technology alliances

: Focusing on the search and the utilization stages

기술제휴 수행에 영향을 미치는 요인들

: 탐색과 활용 단계를 중심으로

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Graduate School of Seoul National University

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이 논문을 공학박사학위 논문으로 제출함

2012 년 **8** 월

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ABSTRACT

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: Focusing on the search and the utilization stages

Gunno Park

Technology alliances are strategic tools useful but hard to make use of. For a number of firms which try to procure insufficient resources from outside, utilization of technology alliances is not optional but essential. However, recent studies point out that the success rate of technology alliances is lower than expected. Although many researchers have verified the excellence of technology alliances, one of the external sourcing tools, for decades, there has been little study that addresses the issue, 'How could we take advantage of this tool for the effective implementation of the technology alliance?' As a result, there has been no guidance for exemplary utilization of technology alliances in the working group's perspective, which resulted in the low success rate of technology alliances.

This dissertation, therefore, addresses effective implementation of

technology alliances with the aim to solve the issue stated above as not yet handled. Specifically, this dissertation has the following two goals: First, to systematize the technology alliance development process centering on the search stage and utilization stage; and to present the guidance for effective implementation of technology alliances step by step. Second, this dissertation includes the empirical study on the four major issues for each step that belong to the search and utilization stages in order to enhance the reliability of suggestions for each step.

The body consists of the four steps - ‘choice step’ and ‘partner selection step’ that belong to the search stage, and ‘execution step’ and ‘management step’ that belong to the utilization stage. It also includes the empirical study on the major issues in each step. In addition, the specific four steps of ‘choice, partner selection, execution, and management step’ make up the development process in the same order of the decision-making of technology alliances.

The ‘choice step,’ which is the first step of the technology alliance development process, is covered in Chapter 3. This chapter has the following two goals: first, the effect of an organizational routine that is formed based on past experiences on the decision-making process to select technology alliances; and second, the effect of the use of technology alliances on the internal R&D capability of the organization. As a result of the analysis of

1,036 technology alliance case in US nano-biotechnology industry, it turned out that firms with more experiences of making use of technology alliances as an external sourcing strategy would choose alliances, and that the excessive use of technology alliance strategies may lead to negligence of investment in internal R&D.

The following chapter, Chapter 4 covers the ‘partner selection step.’ The study of this chapter suggests the three factors to be taken into consideration in order to analyze the effect of relative partner characteristics on alliances performance in investigating partners. To set the variables, the ‘dyadic perspective’ is introduced and the relation between partner characteristics and focal firms is examined. From 96 focal firms in IT industry which are listed on the Korean stock market, 276 technology alliances cases were collected. As a result of the analysis, the following two significances have been drawn out. First, as the technology capability of a partner firm is high, as the technology similarity index is high, and the knowledge delivery capacity of the partner firm is high, the positive effect on the alliance success turned out to be more significant. Thus, it is suggested to choose the most appropriate partner after taking into consideration of the three characteristics of partners as stated above. Second, the resource size of a partner firm, in general, is of an inverted U-shape, which has positive effects. Therefore, it is warned that a technology alliance between a small/medium size firm and a large firm, whose business scales are very different from each other, could interfere with enhancing the achievement.

The ‘execution step’ is covered in Chapter 5. This chapter suggests specific ways of utilizing technology alliances after a firm chooses external sourcing strategies and proceeds with the search stage to investigate the partner. More specifically, this study focuses on the effective way of utilizing technology alliances when a firm advances into an emerging market in an effort to create a new business. To this end, the effect of the difference in the firm’s initial values when advancing into an emerging market such as entry age and size on the achievement of innovation is hypothetically analyzed. Then whether the use of technology alliances strengthens or weakens the effect above after its advancement into the market is hypothetically analyzed. For the analysis, the 73 technology alliance cases of global PV manufacturing firms were collected, and then patents and financial data were added to form the finalized dataset. As a result of analyzing by means of the negative binomial analysis, the following three major significances are drawn out: First, entering the market earlier than competitors consistently works more beneficially for innovation performance than does firm size. Second, empirical results reveal that after market entrance, collaboration strategy of the firm is positively related to innovation performance. Third, however, any positive effect of collaboration is relatively diminished for early entrants. In contrast, the effect holds true for late entrants who require aggressive collaboration.

The last step of the technology alliance development process suggested in this dissertation, the ‘management step,’ is covered in Chapter 6. Modern-day firms make agreements with various partners, and thus are required to manage the competitive embeddedness reflected in the alliance network. To analyze competitive embeddedness, 2539 technology alliance cases were collected from biotechnology-pharmaceutical industry, and then data from 159 alliance portfolio networks were established. As a result of the analysis, which involved the specification of the effect of competitive embeddedness out of the alliance portfolio network in terms of breadth and depth, it turned out that there is a negative effect on the achievement of innovation. In addition, it is suggested to put forth effects to secure the technological status in order to systematically manage in the focal firm’s perspective.

This dissertation presents the following three significances: First, it presents the technology alliance development process, which has been neglected in existing studies, to provide the guidance for the effective implementation of a technology alliance for the working group. Second, it secures the clarity and materiality by establishing the four specific steps that belong to the search and utilization stage. Lastly, it implements the faithful

empirical study for each step to overcome the limitation of existing studies which have presented factors of success based on case studies and meta-analysis of a few studies.

Keywords: technology alliances, development process, organizational routine, partner characteristics, entry conditions, competitive embeddedness

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Table of Contents

List of Tables

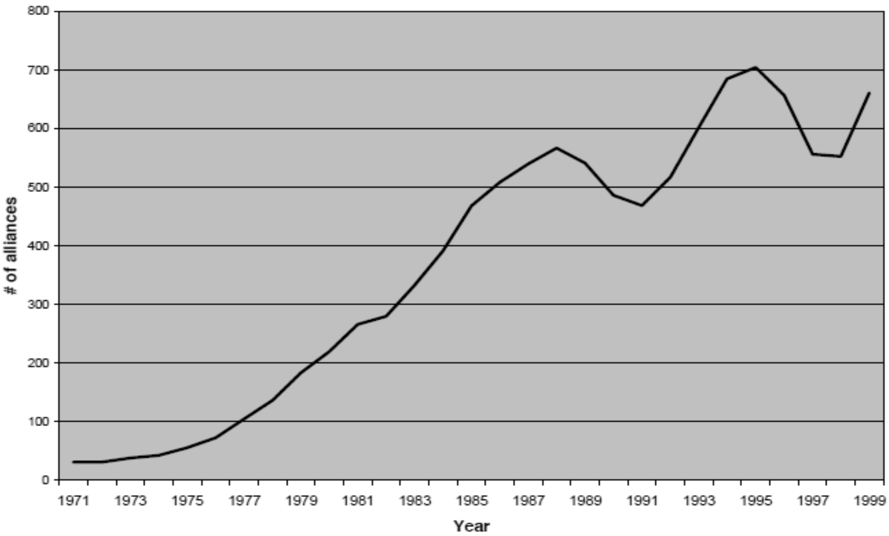
List of Figures

Chapter 1. Introduction

1.1. Backgrounds

The past decades have witnessed a paradigm shift from an in-house innovation model, where firms develop and commercialize their own knowledge toward an open innovation model, where firms develop and commercialize both their own knowledge as well as innovations from other firms and seek ways to bring their knowledge to the market by deploying pathways outside their businesses (Chesbrough, 2003; 2005). Technology alliances have been recognized as an important strategic tool to support such a paradigm shift (Neyens, Faems and Sels, 2010; Vanhaverbeke, 2006).

Figure 1-1. Number of newly established technology alliance (1970-2000), 3-year moving averages, source: MERIT-CATI (de Man and Duysters, 2003)



Since the 1980s, the rapid growth of technology alliances has changed the competitive landscape. Technology alliances have become an important competitive weapon for firms contending in an increasingly hostile international environment. It allows them to efficiently leverage their assets, to participate in emerging technologies and to strategically re-position themselves in different market segments. By allying with technology partners firms are able to share risks and costs associated with technological research and development. At the same time, they are able to reduce development time because of complementarities in skills and assets among technology alliance partners (Sadowski, Duysters and Sadowski-Rasters, 2005; de Man and Duysters, 2005; Dyer, 2000).

However, in spite of these noted advantages of technology alliances, some of the recent studies concern about the high failure rate. Sadowski, Duysters and Sadowski-Rasters (2005) reported that the percentage of termination before the technology alliance contract is ended is 40 to 70 percent. Similarly, Wittmann, Hunt and Arnett (2009) states the percentage that in an alliance contract, the parties are not given the expected benefit is up to 70 percent. Kale and Singh (2009) described this problem as ‘alliance paradox.’ This means that although a technology alliance is a very useful strategic tool for firms, but it is difficult to carry it out successfully.

There have been various studies to enhance the success rate of technology alliances, and those are divided into three major categories. First, the characteristics of partners and the frame for partner selection are investigated in order to improve the achievement of alliances as the right selection of partners is the key success factor (Cummings and Holmberg, 2012). Second, interests arise recently among studies that emphasize the importance of alliance management capability, which is an element to manage alliances effectively, and that point out lack of relationship management abilities after an alliance as the cause of technology alliance failures (Wassmer, 2010). Lastly, there have been studies specifically on learning capability of focal firms. A number of studies, which are based on the absorptive capacity concept of Cohen and Levinthal (1990), argue that for an alliance to successfully create knowledge, attention must be paid to R&D activity and absorptive capacity of focal firms.

However, as previous studies present the points focusing on a certain, limited area of complicated technology alliances, they provide only minor knowledge, not enough to be the guidance for successful alliances. In the same context, existing studies do not provide comprehensive, systematic knowledge on the major points to be considered, what to keep in mind in selecting technology alliances, and what to consider for effective utilization of the technology alliance after the conclusion of an agreement (Kale and Singh, 2009).

Some of the studies may integrate alliances in terms of process. For example, Daellenbach and Davenport (2004) classifies the stage of partner selection and that of negotiation to address the importance of reliability of each step. Das and Teng (2002) classifies the alliance development process into three steps - formation, operation and outcome – to test the influence on the environment and condition. However, they are too abstract to provide the working group with the guidance since they simplify the complicated alliance process too much. Further, there has been little study that completes the whole process of technology alliances, which is the very subject of this dissertation.

This dissertation, therefore, has the following goals to satisfy the needs of the practitioners' perspective and to address issues that have not been touched; it integrates the development process of technology alliances in terms of search and utilization; it attempts to contribute to the effective implementation of technology alliances by suggesting issues to be aware of in each step which have not been touched in previous studies and investigating them empirically.

This dissertation addresses the two stages - search stage and utilization stage – in the order that the technology alliance proceeds. More specifically on each step, the search stage is divided into the two steps – the "choice of technology alliances" step to decide the technology alliance among various external sourcing methods such as M&A, JV, etc; and the "partner selection of technology alliances" step to find the appropriate partner. As to the utilization stage, it is divided to the “Execution of technology alliances” step to consider the ways of effectively utilizing the technology alliance and the “Management of technology alliances” step to address the issues of the technology alliance network operation during the process of implementing the technology alliance. Lastly, this dissertation divides the whole process except the termination of alliances into the four specific stages and draw out the integrated process.

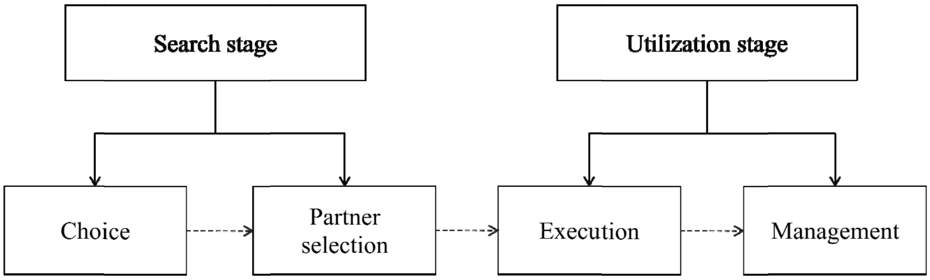


Figure 1-2. Structure of technology alliances deployment process

1.2. Problem statement

This dissertation points out aspects which have not been touched on the search and utilization stage in examination of the technology alliance literatures, and addresses the four research questions that may contribute to this study. Specifically, for the four specific steps - “choice step, partner selection step, execution step, and management step," one key research question is addressed, and the empirical analysis is implemented for it.

First, previous studies focusing on the "choice of technology alliances" stage in examination of the technology alliance are classified into three major categories. First of all, there have been studies that contribute to decision-making on whether to facilitate innovation through internal R&D activity or to utilize external sourcing. Some other studies focus on the governance of cooperation such as M&A, JVs, and alliance among various external sourcing methods. Lastly, there are also discussions on whether the relation between external sourcing methods and that between external sourcing and internal R&D are complementary or alternative. Although this certain area has been discussed a lot, there have been few studies specifically on whether to intervene the decision-making process of technology alliances. Recently, scholars including Zollo, Reuer and Singh (2002) and Hoang and Rothaermel (2008) introduced the concept of an organizational routine in an effort to solve the 'black box' in an organization that affects the decision-making process of alliances, but there are still many issues to be solved in this respect. To address the research question, "what issues are there to be considered by decision-makers with regard to the technology alliance," this study finds out the effect of an organizational routine that may affect the deviations in the decision-making process and the factors that decrease the internal R&D capacity.

Second, the partner selection step is to be addressed right after the first step to decide whether to proceed with the technology alliance. In this step, the question, “With which partner do we have to establish the relation of the technology alliance to improve the achievement of innovation,” is addressed. The matter of partner selection is a popular topic in the technology alliance-related study areas (Gulati, 1998). Although there have been many studies in this regard, there have been few studies that introduce the view that the learning in the relation of alliances results from the correlation between partner firms (Park and Kang, 2009; Lane and Lubatkin, 1998). The dyadic perspective is introduced in the stage to grasp the effect of the partner firm’s relative characteristics on the achievement of innovation, and to verify the adjusting effect of the knowledge absorption capacity of a focal firm and the knowledge delivery capacity of the partner firm.

Third, in the “Execution of technology alliances” stage, the question, “how should the technology alliance be taken advantage of to improve the achievement of innovation,” is answered. The utilization of technology alliances has the following advantages: first of all, it is relatively easy to obtain technology and knowledge. Second, it is utilized for the advancement into a new market. Third, it may be utilized to diversify risks when there are high technological, financial and political risks (Murray and Mahon, 1994). A variety of utilization methods of the technology alliance are regarded as fundamental in previous studies, and are stated to highlight the advantages of the technology alliance. However, there have been studies on the specific methods of utilization fewer than expected. In this dissertation, the empirical study focuses on solar photovoltatic power generation industry, which draws attention with regard to how early entrants and late entrants can make use of technology alliances when advancing into an emerging market by combining factors of technology alliances and entry conditions.

Fourth, the “Management of technology alliances” step provides the guidance for the effective operation after the implementation of the technology alliance. The researchers of strategic alliances or strategic technology alliances have shown interests in the alliance management area as a way of increasing the possibility of effective implementation of technology alliances (Wassermer, 2010; Lavie, 2007). These studies judge that the high rates of failure of actual alliance strategies result from lack of effective operation methods after the conclusion. This dissertation analyzes the alliance portfolio network that makes up a small network centering on focal firms. It also addresses the effect of the competitions among members in an alliance relationship on the focal firm in order to provide the guidance for management methods.

1.3. Research purpose

This dissertation aims to divide the technology alliance development process, which includes the benefits of the technology alliance, selection of partners, appropriate use, and operation, into search and utilization stages. In each stage, the major issues to be considered by decision-makers are selected and analyzed empirically to enhance the reliability of the study results in each step. To achieve the research purpose, various empirical analyses have been implemented in utilization of the technology alliance data, individual firms' financial and patent data in various high-tech industries (such as nanobiotechnology, Korean IT, photovoltaics, bio-pharmaceutical industry) that make good use of the technology alliance. Additional specific objectives of each four steps in this dissertation are stated in the following:

First, in the 'choice step' of technology alliances, firms often execute inefficient technology alliance strategy, thus negatively affecting their innovative capabilities and consequently reducing subsequent innovation performance. Therefore, I try to investigate negative effects of technology alliances on firms' internal R&D capabilities. Also, I test whether firms with greater prior experience on technology alliances are more like to execute inefficient technology alliances strategy. To test two objectives, I employ data from 1,036 technology alliances in US nanobiotechnology industry.

Second, in order to provide insight on 'partner selection step', this dissertation conceptualized an technology alliance structure according to Lane and Lubatkin's 'dyadic perspective', consisting of focal firms which absorb knowledge and partner firms that transfer knowledge. Then I analyzed the relationship between partner firms 'relative characteristics and focal firms' performance of the technology alliances, using the 96 focal firm's 276 technology alliance cases of the Korean IT firms that are listed on Korean stock market during 1999–2005.

Third, in 'execution step of technology alliances', this dissertation examines the multidimensional effects of firm strategy including technology alliances and entry conditions in the emerging photovoltaic industry. Specifically I investigate whether entry age and size have any effects on innovation performance, and how technology alliances and technology portfolio after market entry, strengthen or weaken these effects. To test the hypotheses, I used the Thomsonone database for brokerage reports and searched PV-related news and articles to extract a data of 73 photovoltaics manufacturing global firms.

Finally, I focused on competitive relations among technology alliance partners in the 'management step'. Competitive relations are embedded in the network and have a direct and indirect effect on firms within network. Therefore management of competitive relations in alliance portfolio network is needed to conduct technology alliances efficiently. This dissertation studies following two aspects of competitive embeddedness among partners. First, I examine the influence of competitive relations among partners on focal firm's new technology alliance formation. Second, I examine the moderating effect of focal firm's technological status on the influence of competitive relations among partners on focal firm. For the analysis, I collected 2539 technological alliance cases of 159 alliance portfolio networks in U.S. biotechnology-pharmaceutical industry from 2002 to 2004.

1.4. Research scope and outline

This dissertation is organized with seven chapters as follows. Basically, the dissertation is concerned with two primary modules, such as search and utilization stage, and four specific steps according to technology alliance development process. Figure 1-2 shows the overall structure of the main body, which excludes Chapters 1, 2 and 7.

Chapter 1 discusses general backgrounds of technology alliances research, and the purposes and research organization of the dissertation are mentioned.

This is followed by Chapter 2, which review previous literature on alliance development process. By this means, the chapter addresses the necessity of the development process specialized for technology alliances, and proceeds with stating the search and utilization suggested in this dissertation. Further, as to the specific stages of the search and utilization - choice ➔ partner selection ➔ execution ➔ management, the necessity of empirical studies for each stage, which are focused on in this dissertation, is drawn out through the analysis of previous studies.

The main body of the dissertation consists of four separate studies. In the first search stage, Chapters 3 and 4 highlight choice-, partner selection of technology alliances, the decision-making issue to be addressed when a firm takes into consideration the technology alliance as an external sourcing strategy. In the second utilization stage, Chapters 5 and 6 address execution-, management of technology alliances, which should be covered after a firm adopts the technology alliance.

Specifically, Chapter 3 covers the 'choice of technology' step. The decision-making process of selecting technology alliances is stated in application of the organizational routine theory. Further, the resource based view is applied to make clear that the use of technology alliances may result in the reduction of internal R&D capability, which indicates the need to fully consider the advantages and disadvantages in selecting technology alliances.

Chapter 4 covers the 'partner selection of technology alliances' step. In utilization of the knowledge based view and absorptive capacity theory, the effect of relative partner characteristics such as technology capability, resource size and technology similarity, which affect the achievement of the technology alliance, on the achievement of innovation of a focal firm is clarified too.

Chapter 5 covers the 'execution of technology alliances' step. It explores the way of utilizing technology alliance and technology portfolio strategies depending on the entry size and entry age. The resource based view and real option view are introduced for the logical development. One of the features of this chapter is that it adds brief explanation and data analysis on solar photovoltatic power generation industry, which is recently recognized as an emerging industry.

Chapter 6 examines the 'management of technology alliance' step. This chapter includes the analysis of the alliance portfolio network, which is drawing attention in the technology alliance research area. The concept of competitive embeddedness, which has been known since Gimeno (2004), is expanded to clarify the necessity of managing competitive relations that exist within the alliance portfolio network.

Finally, Chapter 7 summarizes findings and implications in the previous chapters and concludes the dissertation. The limitations as well as contributions of the dissertations are also stated.

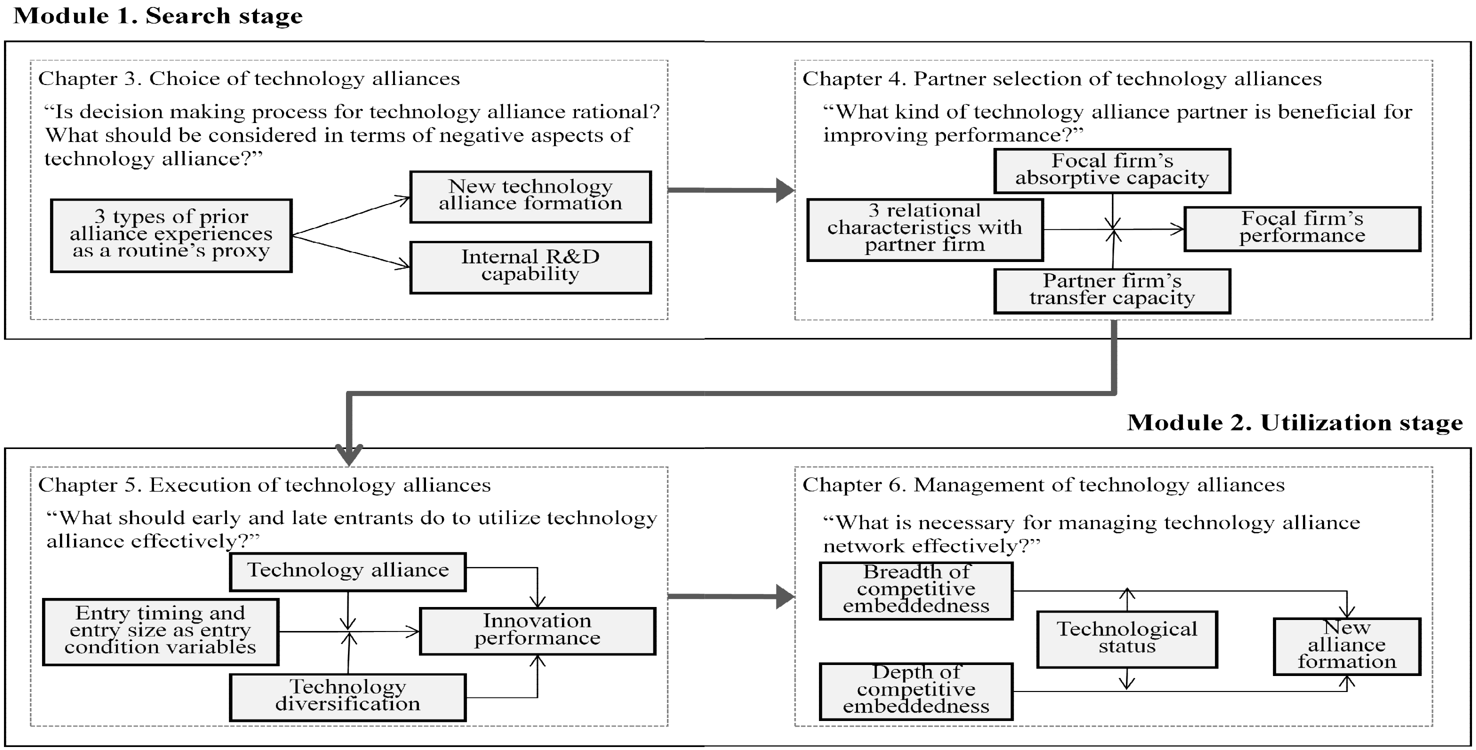


Figure 1-3. Research outline and stepwise flow

Table 1-1. Research summary

	Search stage		**Utilization stage**	
	Chapter 3. Choice of technology alliance	Chapter 4. Partner selection of technology alliance	Chapter 5. Execution of technology alliance	Chapter 6. Management of technology alliance
Purpose	· For rational decision making	· Finding best alliance partner	· For new market entry	· Managing competition pressure in APN
Level of analysis	· Alliance portfolio network	· Dyadic alliance	· Dyadic alliance	· Alliance portfolio network
Main theory	· Organizational routine	· Knowledge based theory	· Resource based view, · Real option	· Network embeddedness · (Social capital theory)
Industry	· Nano-biotechnology industry	· Korean ICT industry	· Solar cell worldwide industry	· Biotechnology-pharmaceutical industry
Method	· Jointly analysis of multiple regression and negative binomial regression	· Multiple regression(OLS)	· Negative binomial regression	· Negative binomial regression, · Zero-inflated negative binomial regression

Chapter 2. Literature review

2.1. Technology alliance development process

2.1.1. Definition and scope of technology alliances

The forms of interfirm partnerships vary from technology alliance, the main focus of this dissertation, to licensing, joint venture, M&A and so on. Some researchers put technology alliance in the field of strategic alliance in a broad sense and some others constrain the definition within research and development (R&D) field. Accordingly, this dissertation needs to clarify the focus of research by defining technology alliance more specifically. In this chapter, technology alliance is to be defined by narrowing down the concept of strategic alliance, which covers technology alliance, and to be clarified by comparing definitions of technology alliance by previous researchers.

Strategic alliances can span one or more parts of the value chain or organizational division and have a variety of organizational configurations typically based on the presence of equity and the contents of partnership contract, such as joint venture (JV), equity-based alliance, and non-equity-based alliance (Kale and Singh, 2009; Yoshino and Rangan, 1995). Figure 2-1 provides an overview of the scope of inter-organizational relationships that can be categorized as strategic alliances. In addition, when the level of technology knowledge and innovation satisfy the goal of cooperation in the certain area, the alliance is called the technology alliance (Hagedoorn, 2002). Furthermore, this dissertation is focused on equity-based technology alliance and non-equity-based technology alliance and excludes technology alliance by joint venture, which establishes new entity financed by the both of allying firms.

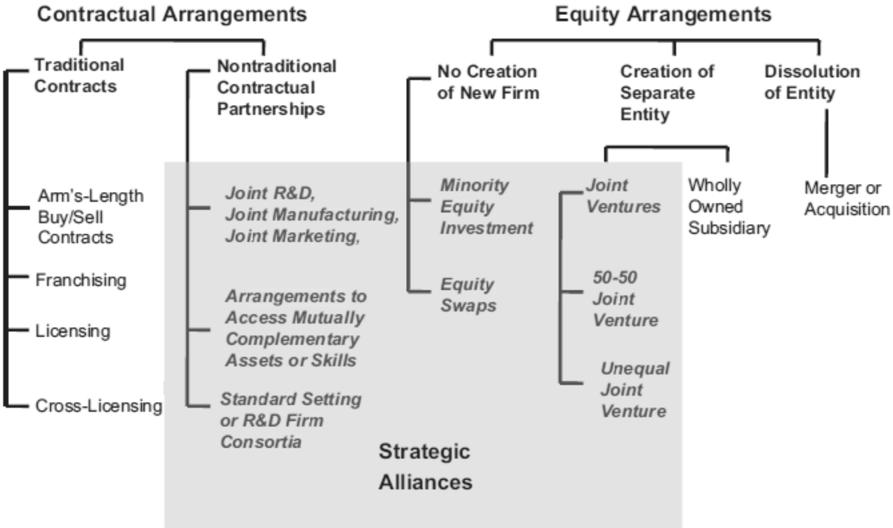


Figure 2-1. Scope of strategic alliances in interfirm relationships

Source: adapted from Yoshino and Rangan (1995) and Kale and Singh (2009)

The concrete meaning of technology alliance is as followings. Technology alliances are a purposive relationship between two or more partner firms that involves the sharing, exchange, or co-development of knowledge or resources to achieve mutually relevant benefits (Park and Kang, 2009; Gulati, 1998). Technology alliances can be defined as strategic alliances aiming at technological development and innovation achievement improvement (Hagedoorn, 2002). De Man and Duysters (2005) and Hagedoorn and Schakenraad (1994) emphasized the strategic goal of technology alliances and call them strategic technology alliances. Other terms used specifically in the area of R&D cooperation are technology R&D alliances (Gomes-Casseres, Hagedoorn and Jaffe, 2006), R&D alliances (Sampson, 2007), and R&D collaboration (Narula, 2004). This dissertation adopts the broad concept of technology alliance adopted by Gulati (1998) and Hagedoorn (2002) among various description of technology alliance.

2.1.2. High failure rates

Technology alliances have become a central part of most firms' competitive and growth strategies. Technology alliances help firms strengthen their competitive advantages by enhancing market power (Kogut, 1991), increasing efficiencies (Ahuja, 2000), accessing new or critical resources or capabilities (Rothaermel and Boeker, 2008), and entering new markets (Garcia-Canal, Duarte, Criado and Llaneza, 2002).

By the turn of current century many of the largest firms had about 20% of their resources, and over 30% of their annual R&D expenditures, tied up in such alliance partnerships (Ernst, 2004). A survey by Partner Alliances reported that over 80% of CEOs of Fortune 1000 firms believed that technology alliances would account for about 26% of their firms' revenues in 2007–08 (Kale and Singh, 2009; Kale, Singh and Bell, 2009). Nevertheless, technology alliances also have been known to exhibit high failure rates (Dyer, Kale and Singh, 2001). Studies have shown that between 30% and 70% of technology alliances fail; in other words, they neither meet the goals among alliance partners nor deliver on the revenue or managerial benefits they purport to provide (Kale and Singh, 2009; Bamford, Gomes-Casseres and Robinson, 2004). Termination rates of technology alliances are also over 50% (Lunnan and Haugland, 2008), and in many cases forming technology alliances has resulted in destruction of market capitalization for the firms that engage in interfirm relationships (Kale, Dyer and Singh, 2002).

Reasons for these high failure rates have always remained rather vague. However, some researchers raise the issue that the study on the technology alliance development process and alliance lifetime frame has been insufficient, and that systematic knowledge has not been delivered to decision-makers (Kale and Singh, 2009; Das and Teng, 2002; Duysters, Kok and Vaandrager, 1999). The success of technology alliances depends on some key factors that are relevant at each stage of alliance development (Gulati, 1998).

2.1.3. Technology alliance development process

The reasons why technology alliances need to be examined in terms of development process in the time sequence are as follows: Unlike common businesses, this is a complicated process among two or more firms, and thus arranging the beginning and end of a technology alliance with necessary specific steps and thus contributing to the success of the technology alliance for each step, in which way necessary points to be aware of is addressed, is essential to improve the achievement of alliances (Kale and Singh, 2009; Das and Teng, 2002; Jarillo, 1988).

Substantial studies have been carried out on technology alliances, especially their motivations, antecedents, formation, and performance. However, with few exceptions (e.g., Kale and Singh, 2009; Das and Teng, 2002; Ring and Van de Ven, 1994), alliance researchers have paid far less attention to the developmental processes of technology alliances, i.e., the development processes through which technology alliances are negotiated, formed, operated, evaluated, reformed, and terminated. Koza and Lewin (1998) list six important areas on alliance research, such as alliance phenomenon, choosing alliances over other governance structures, and alliance performance. However, none of these research areas has a process perspective.

In recent years, some researchers are putting forth efforts to systemize the alliance development process (Kale and Singh, 2009; Das and Teng, 2002; Ring and Van de Ven, 1994). Among studies on the alliance development process, that of Das and Teng (2002) presented in a form of a review paper analyzes and integrates the previous studies on the alliance process, and then presents the finalized process model with the three steps - formation, operation, and outcome. More specifically on each step, the formation stage includes the partner firm approach and alliance negotiating. During operation stage, partner firms collaborate and implement agreements of the technology alliance. In the last outcome stage, the process of visualizing and evaluating the performance is added. Brouther et al. (1997) suggest a five-stage development process of technology alliance that includes selecting operation mode, locating partners, negotiation, managing the alliance, and performance evaluation. Also, Kale and Singh (2009) propose that the alliance development process may be divided into three stages – alliance formation and partner selection stage, alliance governance and design stage, and post-formation alliance management stage. In addition, several development process models have been proposed in the alliance literature.

Despite these efforts, however, understanding of the technology alliance development process remains quite limited. The first limitation of existing studies is that each process study focuses on making the general picture and does not include setting the specific contents for each step. Second, in researchers' perspective, rather than providing the decision-makers with practical knowledge from the beginning to the achievement evaluation, the studies tend to observe such processes merely as an object for the study. Lastly, this type of study may include suggestions based on the cases but with no follow-up empirical analysis. Table 2-1 below outlines the previous studies on the technology alliance process. This dissertation simplifies the technology alliance development process into search and utilization stages to solve the problems in previous studies on the development process, and then add an empirical analysis for each step to enhance persuasiveness.

Table 2-1. Selected alliance process models in the prior literature

Models	Stages	Model summary
Kale and Singh (2009)	3 stages	Formation and partner selection ➔ Governance and design ➔ Postformation alliance management
Das and Teng (2002)	3 stages	Formation ➔ Operation ➔ Outcome
Brouthers et al. (1997)	5 stages	Selecting mode ➔ Locating partners ➔ Negotiation ➔ Managing the alliance ➔ Evaluating performance
Das and Teng (1997)	7 stages	Choosing an alliance ➔ Selecting partners ➔ Negotiation ➔ Setting up the alliance ➔ Operation ➔ Evaluation ➔ Modification
D'Aunno and Zuckman (1987)	4 stages	Emergence of a coalition ➔ Transition to a coalition ➔ Maturity ➔ Crossroads
Kanter (1994)	5 stages	Selection and courtship ➔ Getting engaged ➔ Setting up housekeeping ➔ Learning to collaborate ➔

		Changing within
Ring and Van de Ven (1994)	4 stages	Negotiation ➔ Commitment ➔ Execution ➔ Assessment
Spekman et al. (1996)	7 stages	Anticipation ➔ Engagement ➔Valuation ➔ Coordination ➔ Investment ➔ Stabilization ➔ Decision

In this dissertation, I suggest that technology alliances go through a development process consisting of the two stages of search and utilization. Further, the search and utilization stages have their two sub-steps respectively in order to specify the development process model of technology alliances presented in this study. Additionally, this dissertation selectively includes major issues based on the documentary research for the four sub steps and implements an empirical analysis on them in order to bring up useful significances for decision-makers to implement technology alliances.

Table 2-2. Technology alliance development process focused on search and utilization stages

This dissertation	Search stage		Utilization	
	Choice	Partner selection	Execution	Management
Kale and Singh (2009)		Partner selection		Postformation alliance management
Das and Teng (2002)		Formation		Operation

Brouthers et al. (1997)	Selecting mode	Locating partners		Managing the alliance
Das and Teng (1997)	Choosing an alliance	Selecting partners		Operation
D'Aunno and Zuckman (1987)	Emergence of a coalition			Maturity
Kanter (1994)	Selection and courtship	Getting engaged		
Ring and Van de Ven (1994)			Execution	
Spekman et al. (1996)	Anticipation	Engagement	Investment	Coordination

Literature part, 2.2 search stage of technology alliances specifically examines the previous studies on the 'choice' and 'partner selection,' and addresses the issue of the empirical study to be handled in this dissertation. Then 2.3 utilization stage of technology alliances focuses on the 'execution' and 'management (or operation management)' process that follows the post alliance formation, and addresses the issues to be examined based on the analysis of previous studies in that area.

2.2. Search stage of technology alliances

2.2.1. Choice of technology alliances

A number of studies on the technology alliance development process regard the negotiating step as the initial step for the life cycle of the technology alliance. However, this may ignore the importance of deciding whether external sourcing will be involved before the selection of the technology alliance or internal R&D will be carried out instead (Veugelers and Cassiman, 1999; Lowe and Taylor, 1998; Veugelers, 1997). This study presents the choice of technology alliances as the beginning of the search stage in order to prevent decision-makers from a hasty technology alliance.

When a firm attempts to develop technology or knowledge that does not exist within the firm or to achieve innovation with help from another organization, the first aspect to be considered is whether it will proceed with internal R&D or take advantage of external sourcing (Veugelers and Cassiman, 1999; Lowe and Taylor, 1998; Veugelers, 1997). If it chooses external sourcing, it needs to come up with the most effective collaboration mode among various governances such as technology alliance, Joint Venture (JV), M&A, and so forth (See Figure 2-1).

In reflection of the flow of decision-making above, previous studies on the step of choice can be classified to three major categories: First, there is a research area that contributes to the decision-making of whether the innovation should be achieved by means of internal R&D or external sourcing (Lowe and Taylor, 1998; Veugelers, 1997). This area may include such key words as ‘Make-or-Buy’ and ‘Make-and-Buy’ (Veugelers and Cassiman, 1999). Second, there are studies to find the most effective collaboration governance among various external sourcing methods such as technology alliance, Joint Venture (JV), M&A, and so forth. The most frequently addressed area is the issue of choosing either alliance or M&A (de Man and Duysters, 2005; Hagedoorn and Duysters, 2002). Lastly, the discussion on whether the relation between external sourcing methods and that between external sourcing and internal R&D are complementary or alternative is also a main stream of study (Rothaermel and Alexandre, 2009; Cassiman and Veugelers, 2006; Caloghirou, Kastelli and Tsakanikas, 2004).

Although there have been many discussions on this area, there have been few studies specialized in the issue if intervening the decision-making of a technology alliance. Recently, Zollo, Reuer and Singh (2002) and Hoang and Rothaermel (2005) introduced the concept of the organizational routine in an effort to solve the ‘black box’ within an organization that might affect the decision-making process for an alliance, but there are still many aspects to be addressed. This dissertation addresses in Chapter 3 the research question, “what problems are to be considered by decision-makers in choosing the technology alliance?” Chapter 3 aims to understand the effect of the organizational routine that may affect the decision-making process of external R&D sourcing based on the empirical analysis, and to grasp the effect on the decrease of internal R&D capability.

In addition, the reasons why this dissertation is focused on aforementioned two issues such as external R&D sourcing and internal R&D capability are as followings. The role of internal R&D capability is critical in that it internalizes incoming external knowledge and leads it to practical performance (Teece, Pisan and Shuen, 1997; Cohen and Levinthal, 1990). In other words, external R&D soucing and internal R&D capability interact with each other and result in mechanism which achieves innovation performance. Accordingly, this dissertation is focused on the effect of organizational routine, which is formed by past experience, on two major factors comprising innovation mechanism, external sourcing selection and internal R&D capability.

2.2.2. Partner selection of technology alliances

As decision-makers in firms go through the step of 'choice of technology alliance,' if they choose the technology alliance among various external sourcing methods, then the question that comes up next is, "with whom should we make the technology alliance?"

In the strategic alliance research area, partner selecting is one of the popular study issues (Cumming and Holmberg, 2012). Most of the scholars who studied the technology alliance development process stated above regard the partner selection step as important and as essential in the alliance development process (Kale and Singh, 2009).

Prior technology alliance research has pointed to the critical importance of partner selection to a successful alliance. In addition, many of the literatures on partner selection focus on the area of the focal firm's motivation or partner-attribute consideration (Cumming and Holmberg, 2012; Holmberg and Cumming, 2009; Duysters, Kok and Vaandrager, 1998). First of all, the studies specialized on the focal firm's motivation are as follows: Brouthers, Brouthers and Wilkinson (1995) identified four motivations of focal firm as criteria for searching suitable partners: complementary skills, cooperative skills, compatible goals and commensurate levels of risk focused on asymmetric transfer of information or competencies. Doz and Hamel (1998) identified three motivations of alliance formation: co-opting potential rival firms and complementary firms, achieving co-specialization by combining complementary assets and learning valuable tacit knowledge. Child and Faulkner (1998) grouped alliance formation motivations into the following five categories: transaction-cost motivations, resource-based motivations, strategic-positioning motivations, learning motivations and other motivations. Bierly and Gallagher (2007) studied on the role that intuitive feeling about trust plays compared to a rational approach to partner selection. Besides, some study groups focus on the partner's attributes. The review paper of Shan and Swaminathan (2008) classifies the partner's attributes that affect the success of an alliance into the following three aspects: partner complementarity, partner commitment, and partner compatibility.

However, most of the previous studies on partner selection have the problem of not reflecting the precondition that an alliance is of dyadic relationship. They aim at focal firms, and studies regarding partner characteristics also focus on partners. Recently, Lane and Lubatkin (1998) stated that to accurately understand inter-organizational learning, an analysis in a dyadic view is required to consider both focal and partner. In reflection of this view, Chapter 4 of this dissertation analyzes what different relational partner characteristics may result in regarding alliance performance. In addition, it considers as the variables the learning capability of focal firms and partner firms, which is the goal of forming a technology alliance, and proceeds with the empirical analysis on how such relational partner characteristics are adjusted by the learning capability.

2.3. Utilization stage of technology alliances

2.3.1. Execution of technology alliances

In addition to the choice and partner selection step of the search stage, the 'execution step' discusses the appropriate way of making use of the technology alliance.

Technology alliances have many advantages for firms in that they transfer partners' knowledge to firms and diversify risk under the condition of uncertainty. As evidenced by their ubiquitous use in many different industries, technology alliances have become an important strategic tool (Hagedoorn, 1993). Murray and Mahon (1993) describes the way of utilizing strategic alliances with the five items of organizationally generated use and 10 items of environmentally derived use, 15 in total. As to studies related to the technology alliance among them, the technology alliance may be utilized with 3 different goals in total: acquiring new knowledge and competencies (e.g., Hagedoorn, 1993; Hennart, 1991), sharing financial, political and technological risks (e.g., Hamel et al., 1989; Ohmae, 1989), moving quickly into new markets and technologies (e.g., Kogut, 1991; Park and Kang, 2010).

Specifically, the technology alliance may be used to acquire new knowledge and reduce financial and political risks. Technology alliance to acquire new technology and knowledge is started to be observed since 1980s

(Posner, 1985). Posner(1985) states that firms in computer, telecommunication, and pharmaceutical fields use technology alliance such as contract and equity sharing actively without acquiring shares of other firms. Also, using technology alliance to address rapid technology change has a long history. Wall Street Journal (1989) reports that Canon and Olivetti allied with each other to cope with technological change in image processor and copier, and Corning Glass Works allied with Siemens to develop fiber-optics technology. In case of technology innovation in various fields which one firm cannot cover, it is observed that firms obtain resources through technology alliance (Murray and Mahon, 1993). In this situation, firms enter alliances to hedge their technological and financial risk against various unproved technological alternatives. For example, 7 computer manufacturers in North America including IBM and Hewlett-Packard allied in the early 1990s to implement simultaneous innovations in hardware, software and manufacturing design fields.

Although there could be various strategies to utilize technology alliance, mostly general advantages of technology alliance, there are few studies on specific ways of implementing technology alliance. In other words, among many case studies on technology alliance (e.g., Dittrich and Duysters, 2007; Murray and Mahon, 1993; Kobayashi, 1988; Posner, 1985), there are few empirical research which is focused on effective way to implement technology alliance specifically.

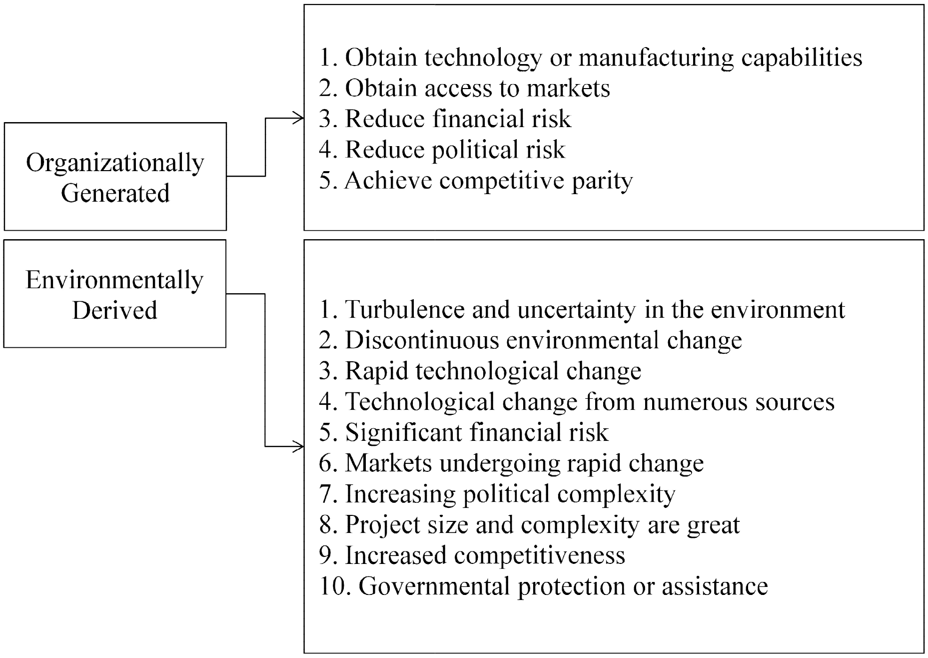


Figure 2-2. Various usage of technology alliances

Source: adapted from Murray and Mahon (1993)

Chapter 5 of this dissertation focuses on the ways of execution the technology alliance aiming to advance into an emerging market. The reasons to address the utilization for emerging markets are as follows: Ever since the subprime economic crisis in 2008, leading firms around the world endeavor to advance into green industries to secure new drivers of growth, and so do Korean firms. This dissertation addresses the ways of utilizing the technology alliance specifically with regard to solar photovoltaic power generation industry, a representative green industry, to provide help in line with the goal stated above. Specifically, the studies in entry condition areas are used to address the ways of utilizing technology alliances in consideration of differences in entry age and entry size.

2. 3. 2. Management of technology alliances

Appropriate decisions linked to choice, partner selection and execution of technology alliances positively affect the likelihood of success of technology alliances. And also, firms must proactively manage an evolving entity such as a technology alliance after it is up and operating (Wassmer, 2010; Kale and Singh, 2009).

Many researchers have emphasized the importance of management after the establishment of a technology alliance (Kelly, Schaan and Joncas, 2002; More and McGrath, 1996). More and McGrath (1996) too attributed alliance success to the ability of firms to effectively manage relationship issues. Wildeman and Erens (1996) suggest that management problems were the cause of the alliance failure of 70% of technology alliances. In the same vein, Kale and Singh (2009) too stated that managing relation of technology alliance after the establishment of an alliance is the key factor to the successful alliance. However, prior alliance research mainly emphasize the qualitative aspects of management such as trust, culture, and chemistry (Kale and Singh, 2009), and relatively little interest was drawn into the management of an alliance portfolio network (Rampersad, Quester and Troshani, 2010; Wassmer, 2010).

The engagement of firms in a wide array of alliances has become a ubiquitous phenomenon in current business environment (Contractor and Lorange, 2002; Gulati, 1998). As a consequence, most firms are engaged in multiple simultaneous strategic alliances with different partner firms and are facing the challenge to manage an alliance portfolio network (Anand and Khanna, 2000; Bamford and Ernst, 2002; Doz and Hamel, 1998; George, Zahra, Wheatley and Khan, 2001; Gulati, 1998; Hoffmann, 2005, 2007; Lavie, 2006, 2007; Lavie and Miller, 2008). According to the investigation of Lavie (2007) on US software industry, a firm formed alliances with more than 30 firms on average in 2000 (See-Figure 2-3).

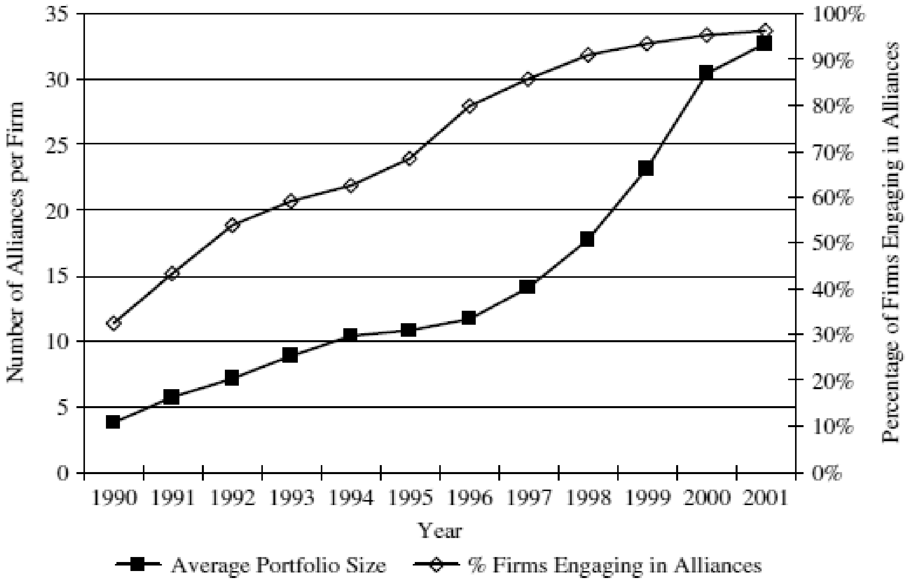


Figure 2-3. Number of alliance per firm in US software industry

Source: adapted from Lavie (2007)

Research on alliance management restricted to single alliance lacks reality to apply to practice under the situation of multiple alliance partnerships (Kale and Sing, 2009; Wassmer, 2010). This dissertation tries to overcome the limits of previous studies and takes alliance portfolio network which consists of varied alliance partners as a unit of analysis in management step.

Recent previous studies research alliance portfolio network in terms of network embeddedness in consideration of network characteristics of alliance portfolio. First, from relational embeddedness perspective, firms may expand certain parts of their alliance portfolios by engaging in new alliances with already existing (i.e., repeated) alliance partners (Goerzen, 2007; Gulati, 1995; Gulati and Gargiulo, 1999). A history of joint collaboration and the level of trust established between alliance partners influence not only the probability of future alliance formation between the partners but also decisions regarding the governance structure of the future alliance (Gulati, 1995; Gulati and Gargiulo, 1999). The second factor which influences firms' decisions to add alliances to their alliance portfolios is structural embeddedness. From such a perspective, a focal firm and a potential new alliance partner are more likely to engage in a new alliance if they already had prior indirect alliance ties (Gulati and Gargiulo, 1999). Likewise, some previous studies investigate the effect of structural and relational characteristics within network on focal firms but they do not consider the effect of competitive characteristics within network on focal firms (Gimeno, 2004; Lorenzzoni and Lipparini, 1999).

Chapter 6 of this dissertation admits the necessity of studying in terms of network, and thus investigates competitive embeddedness and the effect of competition among partner firms in the network, which has not been addressed in existing studies. In addition, this dissertation investigates how to control competitive embeddedness within focal firm's alliance portfolio network.

Chapter 3. Impact of alliance experience on external R&D sourcing and internal R&D capabilities[1]

3.1. Introduction

Technology alliances are voluntary arrangements between firms to exchange and share knowledge as well as resources with the intent of developing their processes, products, or services (Gulati, 1998). Technology alliances have many advantages for firms in that they transfer partners' knowledge and diversify risk under the condition of uncertainty. As evidenced by their ubiquitous use in many different industries, technology alliances have become an important strategic tool for firms (Hagedoorn, 1993).

However, is it always right that firms choose technology alliance to improve their competency? We can answer this question using the case of Motorola, a leading company in the mobile handset industry. According to a report from Perkins et al. (2008), Motorola's performance peaked thanks to their volume model named Razr 1 in 2006, but in the course of the standard war for smart phones, the company did not release a competitive subsequent

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[1] An earlier version of this chapter is under revision and resubmit process in *Technological Forecasting and Social Change*

product due to excessive technology alliance and M&A strategy, which were costly and did not contribute to making profits. Consequently, in 2008, Motorola decided to split the handset business from its other businesses and, recently, handed over its second position in the market to Samsung Electronics. In the same context, some recent studies argue that technology alliances are less successful than expected. For instance, Kale and Singh (2009) point out that technology alliance is highly likely to fail, and Wittmann, Hunt, and Arnett (2009) emphasize that 70% of technology alliances are not successful. There is no strategy that is totally integrative, so technology alliances may also have negative aspects.

Theories on technology alliances have developed highly among strategy and organizational researchers. Majority of prior research focuses on how technology alliances affect financial and innovation performance (Belderbos, Carree, and Boris Lokshin, 2004; Faems, Looy, and Debackere, 2005) and characteristics (Deeds and Rothaermel, 2003), which can result in successful alliance formation. However, the negative aspects of alliances for firms have not been examined adequately. While researchers including Hitt et al. (1991) have made some progress on investigating the negative aspects of mergers and acquisitions (M&A) between firms, there is almost no prior research in the case of technology alliances. There have been a few studies that examine the negative relationship between technology alliance and innovation performance under specific conditions such as within a short alliance period and on the purpose of cost reduction (Duysters and Hagedoor, 2000; Vanhaverbeke et al, 2001), but these are not sufficient to understand the negative aspects of technology alliance. Accordingly, this study is expected to improve understanding on the negative aspects of technology alliances and to contribute a reasonable decision-making tool for practitioners when they choose an alliance strategy.

I introduce the concept of "organizational routine" to analyze the negative aspects of technology alliances. Organizational routine is mentioned frequently in organizational learning and evolutionary economics. Nelson and Winter (1982) define that it is a "gene" which guides organizational behavior. Routine is constituted by the accumulative experience of firms, and one of its characteristics is path dependency because it is strengthened by continuous experience. I estimate that the organizational routine built by inter-firm alliances brings negative effects for firms. Therefore, I try to analyze how the alliance experience that builds organizational routine affects firms.

This dissertation investigates the influence of alliance experience on focal firm's external R&D sourcing and internal R&D capability. Since external R&D sourcing and internal R&D capability are two major factors which comprise learning mechanisms related with acquiring external knowledge, they are highlighted in this dissertation. In case of research of Teece, Pisano, and Shuen (1997), and Cohen and Levinthal (1990), external knowledge and resource flows into the boundary of focal firm through external R&D sourcing. They suggest the importance of internal R&D capability which internalizes and processes external knowledge and resource effectively. Accordingly, it is essential to consider two factors together in making decisions of external R&D sourcing. This dissertation accepts the suggestion of these previous studies and analyzes the effect of alliance experienced on external R&D sourcing and internal R&D capability. In addition, measuring external R&D sourcing is focused on technology alliance which is the very representative knowledge sourcing strategy.

Specifically, the specific steps of this research are as follows. First, I confirm the fact that alliance experience affects firms in their choice of strategies. More specifically, I suggest the possibility that firms' choice of strategies does not result from reasonable decision making but from organizational inertia. Second, I argue that alliance experience decreases the internal research and development (R&D) capability of firms so that I can understand why technology alliances have negative aspects for firms. For an empirical test, I collect 1,036 technology alliance cases in the US nanobiotechnology industry, and combine the financial and patent information of each company to constitute data set. This data set is then analyzed using negative binomial regression and multiple regression.

This work has four different sections. First, I review prior research on alliance experience to establish the logical backgrounds of relationships between alliance experience and alliance formation, and alliance experience and internal R&D capability, in order to set the hypotheses. Second, I describe the sample, variables, and regression analysis in the Methodology part. Then I present the findings in the Results section, followed by the Discussions and Conclusions part in the final section.

3.2. Theoretical background and hypotheses

3.2.1. Organizational routine and technology alliance

Organizational routine has become a cornerstone in theories on organizational learning and evolutionary economics (Nelson and Winter, 1982; Levitt and March, 1988; Cohen, 1991; Walsh and Ungson, 1991; Becker, 2004). However, despite its increasing popularity, there are inconsistencies in explaining the concept involved. This is because organizational routine is difficult to define exactly given its abstract and dynamic characteristics. But generally, it can be summarized as three different things: a gene which guides organizational behavior (Nelson and Winter, 1982), a grammar which typifies patterns of behavior (Pentland and Rueter, 1994), and a program that controls behavior (March and Simon, 1958). According to earlier research on organizational behavior, organizational routine is built up by past experience, and it affects future organizational behavior. In particular, organizational behavior is not determined by decision but rather by automatic responses as an effect of organizational routine (Pentland and Rueter, 1994).

Many researchers have increasingly tended to apply the concept of routine to analyze inter-firm cooperation (Barney, 1991; Dyer and Singh, 1998; Ireland, Hitt, and Vaidyamath, 2002; Hagedoorn and Duysters, 2002; Kale, Dyer, and Singh, 2002; Hoang and Rothaermel, 2005; Rothaermel and Deeds, 2006; Ru, 2009). For example, Hagedoorn and Duysters (2002) argue that routine plays a role in firms' decision to choose between M&A and technology alliance strategy, and it also determines firms' tendency to prefer a specific strategy. Hoang and Rothaermel (2005) consider routine as part of the alliance management capability, that is, the capability to manage relationships with partner firms. Zollo, Reuer, and Singh (2002) redefine routine as interorganizational routine which specializes in inter-firm cooperation.

From the point of view of intraorganizational routine, when a specific experience such as inter-firm alliance is repeated accumulatively, an intraorganizational routine that increases the capability to absorb and exploit knowledge in future alliances is formed and results in positive effects on firm performance (Levitt and March, 1988; Barney, 1991). From the point of view of interorganizational routine, accumulative alliance experience improves alliance management capability which enables firms to manage and operate alliances and to acquire outcome. It also improves alliance portfolio capability which enables firms to manage diversified partners effectively (Kale, Dyer, and Singh, 2002; Hoang and Rothaermel, 2005; Rothaermel and Deeds, 2006). I acknowledge two things from the previous studies mentioned earlier. First, prior alliance experience can be used to measure intra- and inter-organizational routine (Kale, Dyer, and Singh, 2002). Second, the effect of intra- and inter- organizational routine is indirect but positive for firm performance. Figure 3-1 depicts the mechanism of the effect of organizational routine.

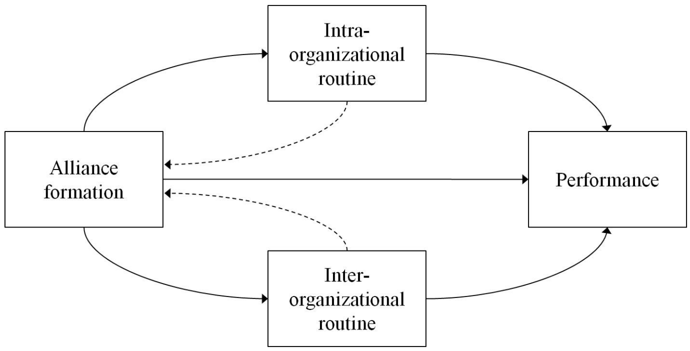

Figure 3-1. Organizational routine′s operating mechanism

Source: adapted from Zollo and Winter (2002) and Heimeriks and Duysters (2007)

This study attempts to approach organizational routine from a different point of view compared with prior research. Organizational routine is basically a concept that excludes value judgment. It plays a positive role in improving firm performance by allowing quick decision making and operational efficiency according to its use. At the same time, however, it can play some negative roles such as rigid decision making and resistance to variety. By focusing on the latter, the present work suggests that organizational routine can have a negative effect on firms' decision-making processes and internal R&D capability. Specifically, I suggest that routine interferes with reasonable decision making when organizations choose a strategy, leading them to make passive decisions because of previous experience. In addition, firms' preference developed by path dependency can have a negative effect on internal R&D capability. Furthermore, I complement the defects of prior research which measure routine only by the total sum of prior alliance experience. This is achieved through refining variables for alliance experience into three different ones, namely, accumulative alliance experience, recent alliance experience, and diversified alliance experience, in order to analyze the negative aspects of routine more specifically and in a multi-dimensional manner.

3.2.2. Alliance experience and alliance formation

The technology alliance literature has provided empirical evidence for the positive effects of alliance formation on firm performance. Using cardiovascular drug discovery industry data, biotechnology industry data, aircraft engine control systems industry data, and cross-sectional data, Henderson (1994), Orsenigo et al. (2001), Brusoni et al. (2001), and Mowery et al. (1996) have respectively found that established firms with multi-technology and intense R&D activities are very skillful in absorbing new knowledge generated outside firm boundaries. Many researchers have also investigated the advantages of technology alliances, which are well known to practitioners. Technology alliance helps firms strengthen their competitiveness by enhancing market power (Kogut, 1991), accessing external resources and capabilities (Rothaermel and Boeker, 2008), and entering new markets (Garcia-Canal, Duarte, Criado, and Llaneza, 2002; Park and Kang, 2010). Consequently, alliance strategy is highlighted as a frequently used firm strategy by managers during the last two centuries (Hagedoorn, 1993).

However, recent prior research suggests that technology alliance is more probable to fail than expected (Kale and Singh, 2009; Wittmann, Hunt, and Arnett, 2009). Kale and Singh (2009) point out that technology alliance is highly likely to fail, and Wittmann, Hunt, and Arnett (2009) also emphasize that 70% of technology alliances are not successful. In many cases, the formation of such relationships has resulted in shareholder value destruction for those firms that engage in them (Kale, Dyer, and Singh, 2002). Despite the prevalence of technology alliances, their low success rate affirms their misuse by decision makers or managers.

In this section, I focus on the organizational decision-making process. Motorola carried on an excessive alliance strategy based on unreasonable judgment. In the mid-2000s, for instance, it allied with various partners such as Compal and CMCS in Taiwan and Pantech in South Korea to launch new products and to reinforce competitiveness in handset division. However, problems in product standardization and compatibility emerged between partners. Motorola promoted platform integration to resolve these problems and fostered sequential alliances to develop a platform-related technology. However, this strategy did not work out. Despite its successive failure, Motorola acquired patents of a British handset manufacturer, Sendo, in 2005 and shares of a platform developer, TTP Com, to procure the technology necessary for platform integration outside the firm boundary. Why did Motorola stick to the alliance strategy despite its successive failure? Why do firms like Motorola, which have talented manpower, adopt excessive alliance and fail? I conjecture that these firms made unreasonable decisions because of the effect of organizational routine built up and improved by past alliance experience.

Generally, firms have path dependency in absorbing external knowledge (Arthur, 1989). For example, once a firm has chosen alliance for absorbing external knowledge, they accumulate capabilities of searching and selecting partners, and executing and maintaining alliances. Afterward, they build a preference for alliance strategy (Powell et al., 1996; Hagedoorn and Duysters, 2002). Osborn and Hagedoorn (1997) state that from the perspective of institutionalization theory, companies search for a ″rule of conduct″ with regard to different forms of organizations that are not only embedded in particular industrial settings but are also copied over time as they become institutionalized within companies. Harrigan and Newman (1990) indicate that the propensity of firms to seek alliances is an important characteristic of differences with respect to the behavior of firms in this context.

Various terminologies in previous research (i.e., preference, path dependency, and rule of conduct) explain the characteristics of organizational routine. I reorganize the conclusions of prior research through an organizational routine lens. If firms have continuously carried out alliance strategy, organizational routine for forming and facilitating alliance strategy is built up, and its characteristic of path dependency strengthens and induces itself to grow. In other words, decisions after building up organizational routine are not made by reasonable judgment, but by unreasonable and biased judgment. These negative aspects of organizational routine induce firms to establish excessive alliance strategy, which can harm firms′ fundamentals.

In this paper, I set past alliance experience as proxy for organizational routine and suggest hypotheses how organizational routine affect alliance formation. Additionally I classify alliance experience into accumulative alliance experience, recent alliance experience and diversified alliance experience to analyze the effect of organizational routine on alliance formation specifically.

Hypothesis 1-1. The more accumulative alliance experience firms have, the more likely they will choose alliance strategy subsequently.

Hypothesis 1-2. The more recent alliance experience firms have, the more likely they will choose alliance strategy subsequently.

Hypothesis 1-3. The more diversified alliance experience firms have,

the more likely they will choose alliance strategy subsequently.

3.2.3. Alliance experience and internal R&D capability

Utilizing external resource through alliance strategy is important under the condition of rapid change of firms' environment (Bettis and Hitt, 1995; Nicholls-Nixon and Woo, 2003; Dittrich and Duysters, 2007; Kranenburg and Hagedoorn, 2008). However, the core body that makes innovation is a focal firm. The improvement of internal R&D capability is also closely related to the survival of firms who compete through technological innovation (Christensen, 2000; Foster and Kaplan, 2001). Many researchers have emphasized the importance of internal R&D capability and have analyzed its relationship with innovation performance (Hagedoorn and Duysters, 2002; Love and Roper, 2002; Griffith et al., 2004; Lokshin et al., 2008). Internal R&D capability is a core asset for firms that aim to achieve innovation (Griliches, 1979; Scherer, 1982; Rothaermel and Hess, 2007). They make innovation happen through investments on internal R&D and the "learning by doing" process (Winter, 1987; Prahalad and Hamel, 1990). There are also some studies which emphasize the interaction between internal R&D capability and utilizing external knowledge resource. Teece, Pisano, and Shuen (1997) argues that internal innovation capability is essential to make innovation through knowledge transfer from external firms. In other words, utilizing external knowledge resource is complementary to internal R&D capability. In the same context, Lokshin et al. (2008) and Lee et al. (2001) also find that combining internal R&D capability and technology alliance contributes significantly to productivity growth, with the positive effect of technology alliance “only evident” in the case of sufficient internal R&D capabilities. Cohen and Levinthal (1990) suggest the concept of absorptive capacity, the capability to utilize external knowledge, and emphasize the importance of internal R&D effort to absorb and internalize external knowledge resource. As mentioned in many previous studies such as those of Griliches (1979) and Scherer (1982), internal R&D capability is critical to the innovation and growth of firms, Furthermore, it is a very important asset that determines the efficiency of cooperation with external firms.

Some recent research, however, suggest that alliance strategy, including technology alliance, has a negative effect on internal R&D capability (Higgins and Rodriguez, 2006; Laursen and Salter, 2006; Watkins and Paff, 2009). The reasons of negative relationships between forming technology alliance and internal R&D capability are as follows. First, alliance formation and internal R&D capability have a trade-off relationship. In the context of the resource-based view, executing alliance strategy allocates firms′ limited human and physical resource to alliance activities, which means a decrease of resource to invest in internal R&D activities. This reduces internal R&D activities and consequently weakens firms' innovation capability in the long run (Hitt et al., 1991; Quinn, 1992; Miles and Snow, 1992; Dodgson, 1993). Second, alliance formation processes usually absorb considerable managerial attention. During this process, the attention of top managers and managing functions may be diverted from internal R&D activities, such as developing new products and innovation (Hitt et al., 1990). Third, due to a lack of absorptive capacity, firms cannot fully transfer knowledge into their boundaries. Specifically, when firms reduce efforts for knowledge creation through internal R&D activities, the extent to which knowledge transfers into the firms decreases due to the decrease of absorptive capacity and can result in forming a vicious cycle (Cohen and Levinthal, 1989; 1990; Lokshin et al., 2008).

The problems mentioned earlier, namely, the negative effects of alliance strategy on internal R&D capability, would stand out in bold relief in the case of firms that have ever chosen a number of alliance strategies in the past. The more alliance experience firms have, the more likely it is that they put less resource on internal R&D area in the past. Most of all, the more alliance experience firms have, the more likely firms will strengthen their organizational routine and specialize for the execution of alliance. I also suggest that this relationship leads to the carrying out of excessive alliance strategy and the decreasing interest on internal R&D area. In this paper, I set and test the hypothesis which proves the correlation between strong organizational routine for alliance strategy, in other words, abundant alliance experience and negative aspects of internal R&D capability. I classify variables for alliance experience into accumulative alliance experience, recent alliance experience, and diversified alliance experience as well, similar to Hypothesis 1.

> ***Hypothesis 2-1. The more accumulative alliance experience firms have, the larger the negative effects on firms' internal R&D capability.***

> ***Hypothesis 2-2. The more recent alliance experience firms have, the larger the negative effects on firms' internal R&D capability.***

> ***Hypothesis 2-3. The more diversified alliance experience firms have, the larger the negative effects on firms' internal R&D capability.***

3.3. Methods

3.3.1. Data and sample

To test the hypotheses, I collect data from nanobiotechnology firms. Nanobiotechnology is a cross-disciplinary area combining nanotechnology, which analyzes atoms and molecules in nanoscale, and biotechnology, which examines diseases and biological phenomena, to produce related products (OECD, 2005; No and Park, 2010). This field is relatively young as research on it has begun only in the recent decade. Nevertheless, biotechnology and pharmaceutical incumbent firms have increased their R&D investment in nanobiotechnology for growth in the next generation; in fact, the US and Japan support R&D in nanobiotechnology at the national level (Thomas and Acuom-Narvaez, 2006; Koopmans and Aggeli, 2010). Also, nano-biotechnology is one of the fastest emerging segments in the nanotechnology field (Roco, 2003; Roco and Bainbridge, 2003).

Collection of data was done as follows. First, I obtained the technology alliance sample of nanobiotechnology firms in the US provided by the Bioscan database from 1990 to 2008. Next, I added financial information such as sales, number of employees, and size of R&D investment provided by the Datastream database. Finally, I added patent information provided by the US Patent and Trademark Office. A total of 1,036 technology alliance samples from 136 firms were collected. Samples comprise four technological groups:

dendrimer, nanoparticle, drug delivery, and therapeutics.

The reasons for choosing the nanobiotechnology industry are as follows. First, nanobiotechnology is a cross-disciplinary field which combines nanotechnology and biotechnology. Therefore, it requires knowledge from different fields such as physics, biology, chemistry, and the engineering sciences (OECD, 2005; No and Park, 2010). Considering these characteristics of a cross-disciplinary technology, there is active cooperation among firms for the development of technology and to achieve innovation (Roco, 2003; Thomas and Acuco, 2003; 2006; Rothaermel and Thursby, 2007). Accordingly, it is appropriate to test empirically for organizational routine built up by alliance experience thanks to a vast array of technology alliance data. Second, the emergence of nanobiotechnology is a radical technological change for biotechnology incumbents (Rothaermel and Thursby, 2007). In fact, the incumbents in biotechnology sectors carry out active M&A and technology alliance to acquire nanotechnology, and the pace at which they are doing so is also growing. However, previous literature has still focused largely on the technology alliance case within solely biotechnology despite the industrial and technological significance of nanobiotechnology (Powell et al., 1996; George et al., 2001; De Carolis, 2003; Zhang, Daden-Fuller, and Mangematin, 2007; Carayannopoulos and Auster, 2010). Accordingly, I use data from the nanobiotechnology industry so I can ensure the possibility of technology alliance research within the industry and so I can improve understanding of the industry. Finally, precise data are available within a single industry and this raises the reliability for test results because controlling the industry is not necessary (Brouthers and Hennart, 2007).

3.3.2. Dependent variables

We introduce two dependent variables, *alliance formation* and *internal R&D capability*. *Alliance formation* is the number of total technology alliances made by focal firms from 2007 to 2008. Searching for a potential alliance partner and processing the contract take time. Therefore, I can reduce bias from this problem when I count alliance committed during two years.

Internal R&D capability is derived from dividing total number of patents with invested R&D expenditure. This calculation is from innovation productivity research, and there is a one-year time lag between R&D expenditure and new patents (Han and Lee, 2007). In this study, I am interested in the change of internal R&D capability. I measure internal R&D capability during 2 years, similar to *Alliance formation*, to reduce the bias derived from an insufficient time window. The equations used for calculation are as follows. And then, a more than 5% decrease is coded into -1 and considered for the decrease of internal R&D capability. I coded it into 0 when internal R&D capability does not change more than 5%, and coded it into 1 when internal R&D capability increases more than 5%.

$$\Delta \text{Internal R\&D capability}_i = \frac{\text{New patents}_{i,2007\text{-}2008}}{\text{R\&D expenditure}_{i,2006\text{-}2007}} - \frac{\text{New patents}_{i,2005\text{-}2006}}{\text{R\&D expenditure}_{i,2004\text{-}2005}}$$

In addition, some previous literature adopts R&D expense or R&D spending as variables for measuring internal R&D capability (Sakakibara, 1997; Irwin and Klenow, 1996). Generally, previous literature, which uses R&D expense as a dependent variable, assumes that a high level of R&D expense is better than a low one. However, this assumption does not reflect the fact that a more effective innovation process or economies of scale lower the R&D expense of firms (de Man and Duysters, 2005). Moreover, it does not explain the case of Motorola which sustained R&D investment but experienced a decrease in capabilities for new product releases. Consequently, this study uses a measure for internal R&D capability which adopts the concept of productivity and efficiency instead of a measure for R&D expense.

The change of internal R&D capability is coded simply into -1, 0, and 1 in this dissertation and this has two advantages as followings. First, this codification reduces bias derived from abnormal increases and decreases of few data which have effect on result. For example, in case of Albany Molecular Research, a producer of chemistry products for antibacterials, they show 272.6% increase of internal R&D capability. This figure outperforms

14.3%, the average value of top 10 firms and can be considered as an outlier. Simple codification of the change of internal R&D capability into -1, 0, and 1 reduces the bias from few outliers and increase confidence. Second, noise derived from inflation and so on can be removed by coding minor changes between -5% and 5% into 0. The best way of removing noise is controlling all kinds of variables which affect internal R&D capability but it is practically difficult to carry out for researchers. Especially it is not critically necessary to control variance in case of nanobiotechnology firms since most of them are small and medium sized firms which show high volatility. Therefore, this dissertation codifies meager increase and decrease into 0 and removes noise. The reason why 5% is chosen for the threshold for noise is because this figure is adopted in practice to control volatility. In case of “Conference Board”, which present Consumer Confidence Index (CCI) in North America, they announce officially that increase or decrease greater than 5% is significant change.

3.3.3. Independent variables

Independent variables used for the test are related to prior alliance experience. Prior alliance experience has generally been used as a proxy to measure organizational routine in many prior research (Kale, Dyer, and Singh, 2002;

Hagedoorn and Duyster, 2002; Zollo, Reuer, and Singh, 2002; Hong and Rothaermel, 2005). However, these works have limitations because they measured organizational routine simply by the total sum of prior alliance experience. Therefore, I address the limitations of prior research by refining the independent variables for alliance experience into three different ones, namely, *accumulative alliance experience*, *recent alliance experience*, and *diversified alliance experience*.

The first measurement of *accumulative alliance experience* is the total sum of alliance experience from 1990 to 2006. This method is verified in many earlier research on alliance experience (Anand and Khanna, 2000; Deeds and Hill, 1996; Hoang and Rothaermel, 2005; Kale et al., 2002; Rothaermel, 2001; Rothaermel and Deeds, 2004; Sampson, 2002; Shan et al., 1994; Zollo et al., 2002). Second, *recent alliance experience* is measured by the total sum of alliance experience contracted from 2005 to 2006. There is a term named "recency effect" in cognitive psychology. Recency effect is understood to be the outcome wherein recent past experience highly affects person′s learning and doing. It is rarely applied to firm organization, but Carley (1997), and Carley and Svoboda (1996) test simulated firms on how recent experience makes a difference in organization. Additionally, recent alliance experience is divided by accumulative alliance experience to consider relative size of recent experience in sense of accumulative experience and named *relative recent alliance experience* for additional analysis. Third, *diversified alliance experience* measures the number of alliance experience with different firms from 1990 to 2006. To make this variable effective, Herfindahl Index, usually used for measuring the level of rivalry within an industry, the level of firm's diversification (Berry, 1975), and the level of R&D dispersion (Singh, 2008), is applied to measure *diversified alliance experience* (Misztal, 1998; Chensong et al., 2010). Equations used for calculation is as follows. As the value approaches 1, the focal firm allies with diversified firms. In the calculation, i represents the focal firm, and n_{ij} represents the number of past alliance experience of the focal firm with one of its partners, j.

$$\text{Degree of diversified alliance experience}_i = 1 - \sum_{j=1}^{J} \left(\frac{n_{ij}}{N}\right)^2$$

3.3.4. Control variables

In this study, five control variables are used. First, firm size measures the sales of firms. Considering the cycle of economy, this variable uses the average value of sales from 2004 to 2006. Firm age measures a number of years from the year when the first revenue is realized until 2006. Park and Kang (2010) empirically tested the existence of interaction effect between the difference of entry age and the alliance formation. This is also included for control variables. Prior M&A experience counts the number of M&A contracts published by firms since their establishment up to 2006. Technology capability is controlled. It measures the total number of patents up to 2006. Finally, the variable IPO stands for whether firms did initial public offering (IPO) (coded as 1) or not (coded as 0). IPO means listing on the stock market so that a private company can open its ownership to the public and publicize its financial information. In case of firms which went through IPO, their ownership is decentralized, and they are obliged to publicize their information. Therefore, their decision-making processes such as choosing a strategy is likely to be different from those firms that did not do IPO. Therefore, I control this variable to increase the reliability of the test results and to verify the pure effect of alliance experience.

3.3.5. Empirical estimation method

In this paper, new alliance formation and internal R&D capability are dependent variables. I use different methods according to the distribution of dependent variables. Negative binomial regression model is used to analyze new alliance formation, and multiple regression model is used to analyze internal R&D capability. Table 3-2 shows that new alliance formation is a variable for discrete events having a positive integer value. Mean value is 1.79

and standard deviation is 2.86. In particular, variance is almost two times larger than mean value and shows an overdispersion distribution. In this case, negative binomial regression raises the reliability for results.

Table 3-1. Variable information and measurement in Chapter 3

Variable information		Measurement
Dependent variables	New alliance formation	Number of new alliance formations in year 2007-2008
	Internal R&D capability	$\frac{\text{New patents}_{i,2007\text{-}2008}}{\text{R\&D expenditure}_{i,2006\text{-}2007}} - \frac{\text{New patents}_{i,2005\text{-}2006}}{\text{R\&D expenditure}_{i,2004\text{-}2005}}$ -1 if the value is under -5%, 0 if the value is between -5% and 5%, 1 if the value is over 5%
Independent variables	Accumulative alliance experience	Total number of accumulative alliance experience until 2006
	Recent alliance experience	Number of alliance experiences in year 2005-2006
	Relative recent alliance experience	Recent alliance experience/accumulative alliance experience
	Diversified alliance experience	$1-\sum_{j=1}^{J}(\frac{n_{ij}}{N})^2$
Control variables	Firm size	LN(Average sales size in 2004 -2006)
	Firm age	Post entry active period until 2006, *Firm age*=2006-year at entry
	Prior M&A experience	Number of M&A contracts before year 2006
	Technology capability	Number of accumulative patents before year 2006
	IPO	1 in case of IPO, otherwise 0

Table 3-2. Descriptive statistics and correlations matrix in Chapter 3

Variables	1	2	3	4	5	6	7	8	9	10	11	Mean	SD.
Firm size	1.00											6.75	5.34
Firm age	0.29	1.00										12.91	4.88
M&A experience	-0.18	0.32	1.00									0.35	0.54
Technology capability	0.48	0.47	-0.13	1.00								156.71	400.74
IPO	0.54	0.49	0.18	0.34	1.00							0.53	0.50
accumulative alliance experience	0.44	0.31	-0.04	0.19	0.39	1.00						5.35	8.31
Recent alliance experience	0.29	-0.03	-0.02	0.18	0.24	0.18	1.00					0.44	1.01
Relative recent alliance experience	0.07	-0.22	-0.09	0.16	0.03	-0.02	0.73	1.00				0.91	0.22
Diversified alliance experience	0.04	-0.21	-0.02	-0.17	-0.18	-0.26	-0.20	-0.19	1.00			0.18	0.38
Alliance formation	0.37	-0.12	-0.07	-0.01	0.33	0.52	0.58	0.29	0.03	1.00		1.79	2.86
ΔInternal R&D capability	-0.22	-0.21	-0.19	-0.35	-0.31	-0.28	-0.15	0.13	-0.13	-0.40	1.00	-0.29	0.71

3.4. Results

Table 3-3 and Table 3-4 present the results of negative binomial regression. In addition, model 2 adopts *recent alliance experience* for the independent variable for H1-2 and model 3 adopts *relative recent alliance experience* for the independent variable for H1-2. Since there is no difference between the results of model 2 and model 3, the analysis of result is described by the result of model 2. In model 2, the effect of all variables relating to prior alliance experience was significant. In model 2, the effect of all variables relating to prior alliance experience was significant. First, accumulative alliance experience is positively correlated to future alliance formation, and this relationship is highly significant ($p<0.01$). This result suggests that previous accumulative alliance experience builds organizational routine, which induces firms to continuously form alliances. After an organizational routine is established, a dynamic process emerges between alliance formation and organizational routine (Nelson and Winter, 1982; Zollo, Reuer and Singh, 2002). Consequently, alliance formation induces organizational routine which, in turn, induces another alliance formation. Furthermore, organizational routine is also intensified.

The second independent variable, recent alliance experience, also has a positive relationship with future alliance, and this relationship is highly significant ($p<0.01$). Thus, the more firms have recent alliance experience, the more they tend to form future alliances; this finding supports hypothesis 1-2. In addition, this result suggests that the effect of organizational routine, which induces firms to choose an alliance strategy, can be intensified by recent alliance experience. In other words, the recency effect exists in a firm's decision whether to choose an alliance strategy or not. Hypothesis 1-3 (suggesting diversified alliance experience), which has a positive effect on future alliance formation, is supported. Generally, corporate culture and work process vary from one firm to another. Therefore, various problems occur until the termination of the alliance, for example, in the duration of the alliance contract between firms and in the course of sharing human and physical resources to effect performance. Diversified alliance experience means that organizational routine, which entails contracting and maintaining an alliance relationship smoothly and minimizing the occurrence of potential problems, is built up sufficiently. This leads firms to underestimate the risk of problems occurring in situations in which decision makers have no prior alliance experience and lack information on a partner firm, consequently stimulating firms to choose an alliance strategy.

Table 3-3. Negative binomial regression results for the alliance formation

Depend variable:	Model 1		Model 2	
Alliance formation	Coefficient	S.E	Coefficient	S.E
Control variables				
Firm size	0.192***	0.042	0.096***	0.037
Firm age	-0.154***	0.035	-0.096***	0.031

M&A experience	-0.428	0.281	-0.409*	0.237
Technology capability	-0.001**	0.001	-0.001**	0.001
IPO	1.114***	0.389	0.658**	0.325
Independent variables				
Accumulative alliance experience			0.057***	0.014
Recent alliance experience			0.333***	0.086
Diversify alliance experience			0.739*	0.304
N	136		136	
Log likelihood	-207.229		-193.253	
Pseudo R^2	0.129		0.188	
LR Chi^2	61.39		89.34	
Regression *p*-value	0.000		0.000	

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

Table 3-4. Negative binomial regression results for the alliance formation (cont'd)

Depend variable:	Model 2		Model 3	
Alliance formation	Coefficient	S.E	Coefficient	S.E
Control variables				
Firm size	0.096***	0.037	0.116***	0.038
Firm age	-0.096***	0.031	-0.107***	0.034
M&A experience	-0.409*	0.237	-0.303	0.241
Technology capability	-0.001**	0.001	-0.001***	0.001
IPO	0.658**	0.325	0.780**	0.345
Independent variables				
Accumulative alliance experience	0.057***	0.014	0.063***	0.015
Recent alliance experience	0.333***	0.086		
Relative recent alliance experience			1.422***	0.493
Diversify alliance experience	0.739*	0.304	0.696**	0.327
N	136		136	
Log likelihood	-193.253		-195.858	
Pseudo R^2	0.188		0.177	
LR Chi^2	89.34		84.13	
Regression *p*-value	0.000		0.000	

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

Table 3-5 and Table 3-6 present the results of multiple regression model and those from the test of how prior alliance experience affects the change of internal R&D capability. In the same manner with table 3-4, which shows the result of negative binomial regression, model 5 adopts *recent alliance experience* for the independent variable of H2-2 and model 6 adopts *relative recent alliance experience* for the independent variable of H2-2. Since there is no difference between the result of model 5 and model 6, the analysis of result is described by the result of model 5. The results show that all variables, except recent alliance experience, weaken internal R&D capability. Results for hypothesis 2-1 indicate that accumulative alliance experience decreases internal R&D capability, and the relationship is highly significant ($p<0.01$). Viewed from a resource-based perspective, forming an alliance, which transfers external resource within the boundaries of firms, leads to the reduction of human and physical resources for investing in internal R&D. Cohen and Levinthal's (1989; 1990) absorptive capacity finds the problem of reduced investment in internal R&D. Reduced investment in internal R&D lowers absorptive capacity. This has a negative effect on firms' innovation performance to process and recreate knowledge. Accordingly, much accumulative alliance experience has a negative effect on internal R&D

capability because it induces less investment in internal R&D. Furthermore, hypothesis 2-3, which states that diversified alliance experience has a negative effect on internal R&D capability ($p<0.01$), is also supported. Diversified alliance experience means that firms have established alliance relationships with multiple partners in the past. When firms establish networks with multiple partners, maintaining those relationships is very costly. In addition, establishing alliances with multiple firms nurtures management commitment to focus on alliance activities (Hitt et al., 1991) and to comparatively reduce interest in internal R&D. This problem causes a reduction of internal R&D capability. Table 3-7 shows the test results for the hypotheses mentioned earlier.

Table 3-5. Multiple regression results for the internal R&D capability

Depend variable:	Model 4		Model 5	
∆Internal R&D capability	Coefficient	S.E	Coefficient	S.E
Control variables				
Firm size	-0.004	0.014	0.026*	0.014
Firm age	0.022	0.015	0.022	0.015
M&A experience	-0.343***	0.119	-0.331***	0.112
Technology capability	-0.001***	0.000	-0.001***	0.000
IPO	-0.267*	0.147	-0.280**	0.140
Independent variables				
Accumulative alliance experience			-0.028***	0.007
Recent alliance experience			-0.058	0.056
Diversify alliance experience			-0.617***	0.151
N	136		136	
R-squared	0.2445		0.3832	
Adjusted *R*-squared	0.2143		0.3318	
Regression *p*-value	0.000		0.000	

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

Table 3-6. Multiple regression results for the internal R&D capability (cont'd)

Depend variable:	Model 5		Model 6	
▵Internal R&D capability	Coefficient	S.E	Coefficient	S.E
Control variables				
Firm size	0.026*	0.014	0.022	0.014
Firm age	0.022	0.015	0.040***	0.015
M&A experience	-0.331***	0.112	-0.368***	0.110
Technology capability	-0.001***	0.000	-0.001***	0.000
IPO	-0.280**	0.140	-0.324**	0.137
Independent variables				
Accumulative alliance experience	-0.028***	0.007	-0.028***	0.007
Recent alliance experience	-0.058	0.056		
Relative recent alliance experience			0.607	0.258
Diversify alliance experience	-0.617***	0.151	-0.498***	0.149
N	136		136	
R-squared	0.3832		0.3655	
Adjusted *R*-squared	0.3318		0.3255	
Regression *p*-value	0.000		0.000	

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

Table 3-7. Summary of the hypotheses and results

Hypotheses			Test results
New alliance formation	H1-1	The more firms have accumulative alliance experience, the more they choose alliance strategy subsequently	Supported
	H1-2	The more firms have recent alliance experience, the more they choose alliance	Supported

		strategy subsequently	
	H1-3	The more firms have diversified alliance experience, the more they choose alliance strategy subsequently	Supported
Internal R&D capability	H2-1	The more firms have accumulative alliance experience, the larger negative effects on firm's internal R&D capability	Supported
	H2-2	The more firms have recent alliance experience, the larger negative effects on firm's internal R&D capability	Not supported
	H2-3	The more firms have diversified alliance experience, the larger negative effects on firm's internal R&D capability	Supported

6.5. Discussion

On one hand, technology alliance is an excellent tool with many advantages in that it complements internal resource, diversifies risk, and makes firms enter new markets. On the other hand, it has a negative side in that it induces indiscriminate alliance strategies and reduces internal R&D capability. However, this implication does not suggest that firms should reduce their technology alliance. Instead, I propose that firms should adopt a reasonable alliance strategy in consideration of its and pros and cons.

There are two key findings of this study. First, previous alliance experience induces firms' new alliance formation. It also ascertains that prior alliance experience has a positive effect on the decision to choose a new alliance strategy, and it further accumulates to become an "experience-selection mechanism." In this mechanism, past alliance experience induces firms to select a subsequent alliance strategy, which accumulates into alliance experience again. In other words, the experience-selection mechanism is a circulating process which strengthens organizational routine. When firms create an experience-selection mechanism, they fall into a state of "alliance addiction" due to the strengthened organizational routine. They tend to acquire knowledge outside their boundaries under alliance addiction status, and they also tend to make irrational decisions when selecting an alliance strategy by inertia. "Too much of a good thing" cannot be an exception for the alliance strategy as well. Therefore, managers have to judge carefully whether an alliance is chosen reasonably or not. In addition, the negative relationship between alliance experience and internal R&D capability has been established. When firms choose an alliance strategy frequently, they can lose their long-term competency because of a worsened internal R&D capability. Aside from having a weakened internal R&D capability that damages absorptive capacity, the choice of an alliance strategy frequently makes the transfer by firms of other organizations' knowledge within their boundaries difficult. Firms still need to pay attention to and invest in internal R&D capability even when they ally with their partners with strategic needs.

Finally, I suggest two further directions for future research. First, nanobiotechnology requires further research relating to technology alliance in consideration of the cross-disciplinary characteristics of the technology. Although there is active development of nanobiotechnology in the biotechnology sector, only a few studies have focused on technology alliance in this field. Second, most previous works have investigated the positive aspect of technology alliance. de Man and Duysters (2005) have reviewed 40 papers relating to technology alliance and found that 73% of these examine the positive aspects of technology alliance. In comparison, only 10% of them examine the negative aspects of technology alliance. Therefore, further research on the negative aspects of technology alliance is required to improve its success rate and effective use.

Chapter 4. The effects of teacher firms' characteristics and student firms' absorptive capacity on firm performance in technology alliances[2]

4.1. Introduction

Due to the increasing technology complexity that surrounds firms, technology alliance for achieving innovation through external knowledge has become an important research topic (Ahuja and Katila, 2001; Hagedoorn, 1993). However, a common understanding of technology alliances to date has been limited primarily to 'how' they should be structured and managed. For example, researchers have examined operational issues such as when a firm needs to form alliances to nurture learning (Powell et al., 1996) and how a successful alliance network is made (Tsai, 2001). Far less is known about 'with whom' technology alliances should be formed, and 'what criteria' should be used in selecting its teacher. I address this question by analyzing the performance of technology alliances relationship with teacher firm's characteristics and student firm's absorptive capacity using the empirical data.

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[2] An earlier version of this chapter was published in *International Journal of Innovation Management*, 13(3)

One of the most favored activities for a firm is technology alliance (Leonard-Barton, 1995), which is useful in acquiring external knowledge and know-how from teacher firms (Burt, 1992; Hansen, 1999). Such usefulness increases the importance of technology alliances both qualitatively and quantitatively. As a matter of fact, firms that are selected in ‘Fortune 500’ have 60 technology alliances on average (Dyer et al., 2001). Previous researchers discovered that technology alliance in general benefits firms by enhancing their performances (Gulati and Singh, 1998; Kim and Park, 2008). However, like all other activities, technology alliances are not without disadvantages. According to some previous research that emphasized dyadic relationship between alliance partners, the effectiveness of technology alliances depends on teacher firms’ characteristics (Hitt et al., 1995; Dyer and Singh, 1998; Stuart, 1998). This is owing to the fact that technology alliances consist of two-way relationships, in which knowledge is transferred from the teacher firm to the student firm. That is, the performance of alliance varies according to the teacher firms’ characteristics. Therefore, in order to attain successful alliance, the teacher firms’ characteristics must be considered by the student firms when seeking for alliance teachers.

However, due to insufficient research on the relationship between teacher characteristics and alliance performances, most processes of selecting teacher firms have been conducted without much consideration on their characteristics and as result, even the most sophisticated firms choose their teacher arbitrarily (BCG, 2005). In this research area, some research address the effects of the relative relationship of the characteristics of teacher firms (Dyer and Singh, 1998; Stuart; 1998). But the empirical study on the impact of these characteristics on performance is insufficient.

This paper focuses on the characteristics that firms must consider when seeking its technology alliance teachers. In addition, the teacher selecting process is systematized and generalized through the analysis of the empirical data that are collected from the Korean IT industry. All in all, this paper aims to serve the following two main objectives. First, it analyzes if the performance of technology alliances depends on the teacher firms' relative characteristics, such as technology capability, firm size, technology similarity, and the capability for knowledge transfer. Second, the paper probes if the performance of technology alliances differs based on the interaction between teacher firms' characteristics and student firms' absorptive capacity.

4.2. Existing models and frameworks

4.2.1. Technology alliance and knowledge transfer

Gulati (1998) defined strategic alliance relationship as an exchange process of knowledge, or tangible and intangible voluntary collaborations related to interactive R&D. Capital, technology, and other resources of teacher firms influence the performance of strategic alliances. Mitchell and Singh (1992) assert that strategic alliances allow firms to enter new markets, and facilitate the R&D for new products and services. According to the above definitions, firms can share or transfer resources with one another, and make innovations from these alliances.

The concept of strategic alliance can be divided into two sub-concepts, one in terms of technology alliance and the other in terms of market alliance (Hagedoorn, 1993). Technology alliance is defined as alliance relationships that adopt the technology, patent, and know-how of teacher firms to develop new product and technological innovation. R&D for new product, licensing, exchange of researchers, and sharing manufacture technology are typical examples of technology alliances. Market alliance is defined as alliance relationships that focus on increasing market share, or entry into the new markets. Consignment sales, joint brand, and marketing are examples of market alliances. This paper focuses on technology alliances and looks at the relationship between teacher firm's characteristics and student firm's absorptive capacity.

Many research based on transaction theory (Oxley, 1997), real option (Kogut, 1991; McGrath and MacMillan, 2000), resource-based view

(Hagedoorn et al., 2000), and others have provided insight into the mechanisms that generate innovations from technology alliances. But some recent studies on strategic alliances, particularly the technology alliances, are more focused on the knowledge transfer between firms and learning from teacher firms. Teacher firms of the technology alliance are thought to be the source of external knowledge in some previous research (Inkpen and Beamish, 1997; Lyles and Salk, 1996; Mowery et al., 1996; 1998; Park et al., 1999; Stuart, 2000; Tsai, 2001). The aforementioned approach is in the regime of the organization learning theory and the concept of absorptive capacity (Cohen and Levinthal, 1990) are partly applied.

Firm's participation in the technology alliance network in the knowledge-intensive industry would accelerate knowledge transfer (Powell et al., 1996). Stuart and Podolny (1996) verified that knowledge transfers in technology alliances facilitate innovations and entry into new businesses. Tsai (2001) focused on dyad-level interactions between alliance firms in analyzing the influence of the characteristics of the alliance networks on innovations.

4.2.2. The characteristics of alliance teachers and performance

Prior research on the technology alliance can be categorized as the following: (1) the formation of alliances, (2) the governance of alliances, (3) the evolution of alliances and network, (4) the performance of alliances, and (5) performance advantage for firms entering alliances. Another important criterion in classifying prior research is the viewpoint on the alliance structure: (1) dyadic perspective, and (2) network perspective.

In this paper, I focus on the performance of alliances in the above category, especially on the teacher characteristics that affect the firm's performance, and can be categorized as a research area of performance of alliances and of dyadic perspective. Teacher characteristics, especially in the technology alliance, have received less attention than other areas due to the difficulty in collecting necessary data to compare the alliance performance against teacher characteristics in detail (Gulati, 1998). Table 4-1 is the summary of the comparisons on the key questions in alliance issues with teacher characteristics.

Table 4-1. Dyadic and network perspectives on key issues for alliances (Gulati, 1998)

Research issue	Empirical questions	Dyadic perspective	Network perspective
1. The formation of alliances	Which firms enter alliances?	Pfeffer and nowak, 1976; Mariti and Smiley, 1983	Kogut et al., 1992; Gulati, 1995; Gulati and Westphal, 1997
2. The governance of alliances	Which ex ante factors influence the choice of governance	Pisano et al., 1988; Harrigan, 1987	Zajac and Olsen, 1993; Gulati and Singh, 1998

	structure?		
3. The evolution of alliances and networks	Which ex ante factors and evolutionary Processes influence the development of alliances networks?	Ring and Van De Ven, 1994; Doz, 1996	Nohria and Garcia-Point, 1991; Gomes-Casseres, 1994; Gulati and Gargiulo, 1999
4. The performances of alliances	Which factors influence the performance? Whom do firms choose as alliance teachers?	Harrigan, 1986; Dyer and Singh, 1998; Stuart, 1998	Doz, 1996; Dyer and Singh, 1997; Levinthal and Fichman, 1988; Kogut, 1989
5. Performance advantages of alliances	Do firms receive social and economic benefits from their alliances?	Anand and Khanna, 1997; Baum and Oliver, 1991, 1992	Dyer, 1996; Gulati et al., 1997

Though teacher characteristics have not been sufficiently explored, it is one of the most important factors that leads to successful technology alliance. After deciding to join the alliance, finding the optimal teacher firm becomes the most important step. Although the importance of teacher selection has been recognized in academics and practice, Boston Consulting Group (2005) found that even one of the most sophisticated firms choose teachers arbitrarily, without sufficient considerations. The difficulty in the selection process could be a reason (Hitt et al., 1995; 2000). The performance of technology alliances depends on teacher firm's characteristics (Burt, 1992). That is, teacher firm's characteristics play important role in successful technology alliances (Stuart, 2000).

To verify that performance of technology alliances depends on teacher firm's relative characteristics, I broke down teacher firm's characteristics into four components of technology capability, firm size, technology similarity, and the capability for knowledge transfer. For active knowledge transfer in technology alliances, relative technology capability is considered important (Lane and Lubatkin, 1998; Darr and Kurtzberg, 2000). Song and Kim (2007) also verified that the larger the gap of technology capability between the teacher firm and the student firm, the greater is the increase in the knowledge transfer: there is more chance for the student firm to learn new technology or knowledge from the technologically advanced firm. The lower the knowledge level of the student firm, the more motivated is the firm to learn. Based on these previous research, Hypothesis 1 has been put forward.

Hypothesis 1: The relative technology capability of the teacher firm would have positive influence on the performance of technology alliances.

The bigger-sized teacher firms would have more influence on the performance of technology alliances (Stuart, 2000). Its size is the measure of the difference between the dyad-level sizes of two firms. Large-sized teacher firm have more resources to invest and more capability to transfer knowledge than small-sized one.

Hypothesis 2: The relative firm size of the teacher firm would have positive influence on the performance of technology alliances.

Numerous studies attempts to find and explore technology similarity. Opinions on the influence of technology similarities on performance are diverging among researchers (Sampson, 2007). First, as technology similarity increases, the performance of technology alliances improves (Mowery, Oxley, and Silverman, 1996; Lane and Lubatkin, 1998; Ahuja, 2000). Mowery, Oxley, and Silverman (1996) examines the effect of technology similarity on post-alliance performance and finds that high similarity in knowledge resources can improve alliance performance. Lane and Lubatkin (1998) suggest that greater similarity in knowledge bases between pharmaceutical and biotech firms enhances success rate of alliance. Also, Ahuja (2000) finds a similar result that technological similarity increases post-alliance patenting. Although these studies measure similarity in different methods, the underlying logic is very similar and can be explained by absorptive capacity. Cohen and Levinthal (1990) introduce the concept of absorptive capacity. Absorptive capacity is determined by two factors: the degree of prior (accumulated) knowledge and the intensity of the effort on learning. High similarity between absorbed knowledge from teacher firm and prior knowledge of student firm enables efficient learning. Therefore, technology similarity between these two firms could increase the probability of success in technology alliances. On the other hand, some studies argue that high technology similarity or low diversity would result in adverse influences on performance of technology alliances (Baum, Calabrese, and Silverman, 2000; Chang and Son, 2002; Powell, Koput, and Smith-Doerr, 1996; Keller, 2001). Technology alliances with potential competitors with similar technology could induce technology overlapping and create potential competitive relationships, which influence negatively on performance (Baum, Calabrese, and Silverman, 2000; Chang and Son, 2002). Powell, Koput, and Smith-Doerr (1996) argue that diversity of alliance experience enhances firm's competitive advantage. In other words, firms with different types of alliance partners, such as alliances for R&D, manufacturing, and marketing, tend to grow fast. Also, Ahuja and Katila (2001) argue that firms that have substantial overlap on patents with partners tend to show lower performance in patenting activities.

However, in this paper, the effect of adverse influence is considered to be rather small, because the adverse influence derived from overlap is not significant for student firm who learn mostly from teacher firm. Specifically, research on positive effect of diversity emphasizes the risk of potential competitive relations (Baum, Calabrese, and Silverman, 2000; Chang and Son, 2002) and advantages of utilizing varied functional resources such as manufacturing, marketing (Powell, Koput, and Smith-Doerr, 1996). In other words, they do not view interfirm knowledge transfer or learning, which is the main focus of this paper. Wang (2005) suggests that the expected effect of technology similarity diverges because of different point of views and separates learning aspect from managing aspect. He suggests positive effect of similarity on the learning aspect and negative effect of similarity on the managing aspect. Therefore technology similarity between firms can have positive effects on performance of technology alliances.

> ***Hypothesis 3: The technology similarity with the teacher firm would have positive influence on the performance of technology alliances.***

Capability for knowledge transfer is the last teacher characteristic tested in this paper. Efficient knowledge transfer from the teacher firm to the student firm has direct influence on the performance of technology alliances. Organization learning theory has more focused on absorptive capacity of student firms, while capability of teacher firms has received relatively less attention. But learning is one type of interaction process between the teacher and the student. Therefore, teacher firm's capability for knowledge transfer is as important as that of the student firm. But unfortunately, there is no generally accepted proxy measure for the capability for knowledge transfer. I found and applied proxy measures from Nonaka (1995)'s research. According to Nonaka, knowledge is formed and expanded through dynamic interactions between tacit and codified knowledge. The process of knowledge transfer can be described as 'socialization → externalization → combination → internalization'. Knowledge will accumulate as the process is repeated. Externalization is defined as formulation process through which tacit knowledge is converted into precise concepts and expressed literally. Therefore, the capability to convert tacit knowledge translates as the capability to create knowledge.

Hypothesis 4: The larger capability for knowledge transfer would have positive influence on the performance of technology alliances.

4.2.3. Absorptive capacity of the student firm

Absorptive capacity is defined as a process to understand, internalize, and utilize external knowledge, and is the determinant to successful introduction of external technology and knowledge (Cohen and Levinthal, 1990). In other words, large absorptive capacity indicates broad and profound knowledge base. With this knowledge base, firms can find and absorb external knowledge. The positive feedback is deduced from absorbed knowledge through the enlargement of firm's absorptive capacity (Mowery and Oxley, 1995).

The concept of absorptive capacity has been used to explain alliances. Lane et al. (2001) used the concept in the research on the learning and performance of international JVC. Koza and Lewin (1998) studied the influence of absorptive capacity on the evolution of alliance networks. Lane and Lubatkin (1998) analyzed the learning performances of alliances through 'relative absorptive capacity', a concept that extended from Cohen and Levinthal (1990)'s absorptive capacity. Large absorptive capacity increases the possibility of the alliance contract by exploring external knowledge and enlarging incentives to learn (Lavie and Rosenkopf, 2006).

From experience, I know that students taught by the same teacher differ in their performances. This shows that the performance of technology alliances also depends on the absorptive capacity of student firms.

> ***Hypothesis 5: Student firm's absorptive capacity would have positive influence on the performance of technology alliances.***

Most studies on knowledge transfer have focused on absolute measures of student firms and teacher firms characteristics. However, Lane and Lubatkin (1998) analyzed differences between relative absorptive capacities of teacher firms and student firms. Also, Tsai (2001) verified that the relationship between physical characteristics of the alliance network and absorptive capacity of student firms on firm's innovation. Therefore, learning is generated from the dyadic relationship between firms. The dyadic relationship is analyzed to provide insight into the influence on the performance of technology alliances.

> ***Hypothesis 6: The performance of technology alliances depends on the relationship between teacher firm's characteristics and student firm's absorptive capacity.***

Table 4-2. Summary of the hypotheses

		Hypothesis
Characteristics of teacher firm	H1	The relative technology capability of the teacher firm would have positive influence on the performance of technology alliances.
	H2	The relative firm size of the teacher firm would have positive influence on the performance of technology alliances.
	H3	The technology similarity with the teacher firm would have positive influence on the performance of technology alliances.
	H4	The larger capability for knowledge transfer would have positive influence on the performance of technology alliances.
Characteristics of student firm	H5	Student firm’s absorptive capacity would have positive influence on the performance of technology alliances.
Interaction between teacher and student Firms’ characteristics	H6	The performance of technology alliances depends on the relationship between teacher firm’s characteristics and student firm’s absorptive capacity

4.3. Methods

4.3.1. Data and sample

The data utilized in this study was obtained through the following three steps. First, a list of student firms that have technology alliance experience was collected and compiled. Second, I found the corresponding teacher firm. Third, I collected the finance and patent data representing teacher firm's characteristics.

List of the student firms consists of the firms in the information technology industry listed on the KOSDAQ (Korea Securities Dealers Automated Quotation) an equivalent of NASDAQ in South Korea. In South Korea, IT firm lists are specially managed by KOSDAQ, because the industry is considered a national policy. Information technology firms listed on the KOSDAQ have some noticeable features. These firms are tended to be relatively small and easily founded. Then, I found technology alliance cases of student firms in the period 1999-2005. Due to the booming venture business at the time, technology alliances amongst information technology firms were numerously reported. In general, alliances have various forms and objectives. To collect optimal samples for this study, clarified the definition of technology alliances. Stuart (2000) classified alliances into 4 categories: new product R&D, licensing, technology exchange, and marketing. In this study, the new product R&D and technology exchange are included as technology alliances. Dataset of technology alliance cases were gathered from the FSS (Financial Supervisory Service) in South Korea.

The preliminary dataset included 94 student firms, which were associated with 276 technology alliance cases. 276 technology alliances consists of 154 alliance cases with foreign firms, 82 alliance cases with domestic firms, and 40 alliance cases with institutions or universities. Access to the data for characteristics of teacher firms is limited. Due to the difficulty in collecting the dataset that represent the characteristics of teacher firms, especially on the foreign and small-sized firms, the resulting dataset included 62 technology alliance cases of firm's characteristics such as technology capability, firm size, technology similarity, and capability for knowledge transfer.

Table 4-3. Summary of technology alliance cases

Foreign firm	Institution and university	Domestic firm	Total
154 cases	40 cases	82 cases	276 cases

4.3.2. Dependent variable

Dependent variable in this study is related to student firm's technology alliance performance, which is measured in sales growth rate (Lee, Lee and Pennings, 2001). The sales growth rate is calculated with the sales data of the previous year and the ensuing two years. For example, the sales growth rate of technology alliance in 2002 is calculated by the sales data between 2001 and 2004. I assumed that time lag must be considered for internalization. It takes two years at least for technology alliances to influence performance.

4.3.3. Independent and control variables

Hypotheses 1 to 4 test the relationship between student firm's performance and teacher firm's characteristics such as technology capability, firm size, technology similarity and capability for knowledge transfer.

Teacher firm's technology capability in Hypothesis 1 is measured by teacher firm's cumulative patent number during the five years since joining the technology alliance (Song and Kim, 2007). Teacher firm's size in Hypothesis 2 is the sales in the year of technology alliance (Saxton, 1997, Lane and Lubatkin, 1998). Technology similarity between alliance firms in Hypothesis 3 is measured by using United Nations Standard Products and Services Classification (UNSPC code). The value of technology similarity is assigned '1' if the alliance firms are from the same category, '0' otherwise. Capability for knowledge transfer in Hypothesis 4 is measured by R&D

expenditure of teacher firms (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998). Higher R&D expenditure means that firm's R&D activity is very active. The main purpose of R&D activity is to make and share new knowledge for innovation and enhance firm capability. Nonaka (1995) explained knowledge creation process that generates codified knowledge from tacit knowledge. Therefore, the capability to convert tacit knowledge to codified knowledge is thought to be the capability to transfer knowledge.

Hypothesis 5 tests the influence of student firm's absorptive capacity on the performance of technology alliances. Absorptive capacity has an important role in alliances between firms (Lane and Lubatkin, 1998; Lane et al., 2001; Koza and Lewin, 1998). I measure student firm's absorptive capacity by R&D intensity. The R&D intensity was first introduced by Cohen and Levinthal (1990) to measure absorptive capacity of knowledge. R&D intensity is calculated as R&D expenditure against firm sales. The R&D intensity index is more suitable for knowledge-intense industries, such as bio industries, chemical industries, and computer science industries (Cohen and Levinthal, 1990).

Hypothesis 6 predicts positive association between student firm's performance and the match of student firm's absorptive capacity and teacher firm's characteristics. Interactions between teacher firms and student firms are calculated from the four independent variables of teacher firm's characteristics and student firm's absorptive capacity. Teacher firm's characteristics moderated the student firm's absorptive capacity of knowledge consist of technology capability, firm size, technology similarity, and capability for knowledge transfer. The methodology to verify moderator effects can be seen in Lee, Lee and Pennings (2001), which multiplies the existing variables amongst themselves to acquire the desired new variable.

Lane and Lubatkin (1998) assert that the collective and shared knowledge begets learning effect between two firms. Hagedoorn (1993) comments that efficient technology transfer routines are formed through repeated affiliation, facilitating the learning. Since these theories suggest that the experience from previous affiliation would affect current firm performance, experience has been set as a control variable. To test whether or not having a clear commercial objective between the affiliated firms affects the performance, the comprehensiveness of the affiliation was controlled during the analysis.

Table 4-4. Summary of variables

	Variable	Previous research	Description
Dependent	Firm performance	Lee, Lee and Pennings (2001)	Sales growth rate
Independent	Technology capability	Song and Kim (2007)	Cumulative patent
	Firm size	Sexton (1998)	Sales scale
	Technology similarity	Jang and Son (2002)	UNSPSC code
	Capability for knowledge transfer	Lane and Lubatkin (1998)	R&D intensity of teacher firm
	Absorptive capacity	Cohen and Levinthal (1990)	R&D intensity of student firm

4.4. Results

Table 4-5 shows descriptive statistics and a correlation matrix. The maximum VIF(variance inflation factor) for variables in all of these models is 4.018, which is well below the rule-of-thumb cutoff value of 10 in the multiple regression models (Neter et al., 1985).

Table 4-5. Descriptive statistics and correlation matrix

	Means	S. D.	1	2	3	4	5	6	7	8	9	10
1. Sales variation	1.16	.73	1									
2. Technology capability(1)	1.33	1.21	-.59**	1								
3. Firm size(2)	5.23	1.30	.45*	.82**	1							
4. Technology similarity(3)	.42	.50	.41*	-.22	-.18	1						
5. Capability for knowledge transfer(4)	.05	.06	.17	-.10	-.37	-.03	1					
6. Absorptive capacity(5)	.05	.04	-.06	.10	-.01	-.19	.170	1				
7. (1) x (5)	.07	.09	-.43*	.75**	.55**	-.27	.075	.59**	1			
8. (2) x (5)	.26	.21	-.23	.39*	.34	-.27	.030	.92**	.82**	1		
9. (3) x (5)	.02	.03	.28	-.22	-.26	.70**	.081	.267	-.06	.12	1	
10. (4) x (5)	.00	.00	.12	.03	-.25	-.07	.91**	.45*	.25	.30	.17	1

1) *** means under p-value 0.01, ** means under p-value 0.05, * means under p-value 0.10

Table 4-6. Multicollinearity test

Variable	VIF
Technology capability	3.572
Firm size	4.018
Technology similarity	1.088
Capability for knowledge transfer	1.362
Absorptive capacity	1.082
Technology capability x Absorptive capacity	3.243
Firm size x Absorptive capacity	3.313
Technology similarity x Absorptive capacity	1.120
Capability for knowledge transfer x Absorptive capacity	1.126
Experiences of technology alliance	2.011
Inclusive alliance	1.084

Though VIF indicate that the model is free of multicollinearity problems, I have separated the models to acquire more stable results. Model 1 test only control variables. Model 2 consists of variables representing teacher firm's characteristics. Model 3 consists of variables representing teacher firm's characteristics and student firm's absorptive capacity. And Model 4 includes products variables of teacher firm's and student firm's variables.

Table 4-7. Result of multiple regression analysis (OLS)

Variable	Model 1	Model 2	Model 3	Model 4	Hypothesis
Technology capability		-.455(-2.18)**	-.446(-2.12)**	-.291(-1.42)	Not supported
Technology capability^2		-.753(-2.61)**	-.748(-2.59)**	-.866(-2.42)**	
Firm size		.177(0.82)	.173(0.80)	.133(0.65)	Not supported
Technology similarity		.305(2.53)**	.320(2.61)**	.321(2.07)**	Supported
Capability of knowledge transfer		.269(2.03)*	.266 (2.00)**	.852(2.17)**	Supported
Absorptive capacity			.0815 (0.74)	-.603(-1.61)	Not supported
Technology capability x Absorptive capacity				.439(3.36)***	Supported
Firm size x Absorptive capacity				.074(0.61)	Not supported
Technology similarity x Absorptive capacity				-.119(-0.70)	Not supported
Capability for knowledge transfer x Absorptive capacity				.677(-1.42)	Not supported
Experience of technology alliance	.353(2.92)***	.213(1,74)*	.228(1.83)*	.300(2.41)**	Supported
Inclusive alliance	.334(2.77)***	.047(0.39)	.034(0.28)	.092(0.77)	Not supported
R^2	0.1834	0.4356	0.4412	0.5645	
Adj R^2	0.1557	0.3740	0.3688	0.4687	

1) *** means under p-value 0.01, ** means under p-value 0.05, * means under p-value 0.10

2) In the (), number represents t-value

Table 4-7 presents the results from the multiple regression analysis of alliance performance. Hypothesis 1, the relevance of teacher firm's technology capability is negatively related to the performance of technology alliances. Hypothesis 1 is not supported. Results also indicate that if teacher firm has larger technology knowledge than student firm, teacher has negative influence on the alliance performance. I perform the analysis of adding the regression model to the square of the variable of technology capability in order to survey how the technology capability affects the performance. As a result, the effect of technology capability of teacher firm to alliance performance is shown as an inverted U-shape with its vertex in the second quadrant. This implies that when the difference in technology capability between two firms is small, it has only a small negative influence on the alliance performance. However, the negative effect on the performance increases as the difference in technology capability between firms grows. This can be explained by 'bargaining power'. When the difference in technology capability is large, student firms have practically little bargaining power. The ensuing unbalanced relationship can interfere with the knowledge sharing. Hypothesis 2, teacher firm's size measured sales has no significance in performance. Hypothesis 2 is not found significant. According to previous research on market alliances, large-sized teacher firms have more positive influence on alliance performance than small-sized teacher. The reason is that large-sized teacher firm can easily provide reputation, capital, and other resources to the student firm. But, in the case of technology alliances, it can be explained by the fact that firm's size has nothing to do with developing new technologies, products, and the performance of technology alliances.

The relevance of teacher firm's technology similarity is positively related to performance of technology alliances, thus supporting Hypothesis 3. The results indicate that higher technology similarity between firms has positive influence on the performance of technology alliances. Such results are equivalent to the results from Lane and Lubatkin (1998), verifying the existence of learning effect between two firms that share knowledge. High technology similarity between two firms implies that the firms are producing similar products and services. This in turn is followed by a high probability of having similar resources, such as knowledge, assets, and cultures of the firms. As a result, firms exhibit similar pattern in technology development. That is, the student firms have better chance of increasing their performance if they seek teacher firms with similar knowledge and technology.

Hypothesis 4, teacher firm's capability for knowledge transfer has positive influence on the performance. Thus Hypothesis 4 is supported. Technology alliance is an interactive process between firms to transfer and share knowledge they possess. Therefore, success or failure of technology alliance is largely affected by how well teacher firm can transfer their knowledge.

Hypothesis 5, student firm's absorptive capacity has no significance in performance. Hypothesis 5 is not found significant. After Cohen and Levinthal (1990)'s research, it has been proved by many previous researchers that higher absorptive capacity is effective for organizational learning. But, in this paper, absorptive capacity of learning firms has no significant relationship on alliance performance. This may be owing to the data which are comprised of small- and medium-sized IT firms listed on KOSDAQ. Contrary to large-sized firms, their asset structure takes on a variety of forms, leading to increased volatility. Another reason may be that public announcements on R&D expenditure may differ from actual expenditure.

Hypothesis 6 predicts significant effects of the interaction variables calculated from the products of four independent variables that explain teacher firm's characteristics and student firm's absorptive capacity. 'Technology capability x Absorptive capacity' has a significant effect on performance. This implies that student firm's higher absorptive capacity is facilitated in absorbing teacher firm's knowledge when the teacher has large knowledge sources.

4.5. Discussion

Firms are increasingly relying on acquired knowledge through technology alliance to facilitate and develop their own innovation capabilities. To provide deeper insight on understanding teacher characteristics, this study examined the role of teacher characteristics in the success of technology alliances. I conceptualized the alliance structure according to Lane and Lubatkin (1998)'s dyadic construct that divides the alliance structure into student firms of absorbing knowledge and teacher firms of transferring knowledge. For handling this student-teacher firm alliance structure, I selectively collected technology alliance cases that have been formed between student firm which absorbs knowledge and teacher firm that transfers knowledge. I tested hypotheses after controlling the data set. Finally, I found that technology capability, technology similarity, and capability for knowledge transfer of teacher firms influence the success of technology alliances. Absorptive capacity of student firms, on the other hand, has no significant influence on firm's performances, not supporting Hypothesis 5. Regarding the Hypothesis 6, student firm's absorptive capacity appeared to adjust to a certain degree given high technological capability of the teacher firm.

Several strategic implications can be derived from the results. First, the purpose of the alliance must be clarified before the formation of the alliances. Then according to the purpose, selecting process is needed to find a suitable partner. Secondly, when small- and medium-sized IT firms find technology alliance teachers, preferences for large-sized firms without a specific objective should be reconsidered. Thirdly, for the success of technology alliance, firms should look into teacher characteristics, such as technology capability, technology similarity, and capability for knowledge transfer in advance. Finally, large gaps between firms' technology capabilities are an obstacle for technology alliances.

The present research is subject to some limitations, primarily in the dataset. The dataset used is 62 technology alliance cases, which could be larger. Secondly, student firms' R&D intensity is not the most suitable for measuring small and medium -sized firms' absorptive capacity. In future research, finding better measures for absorptive capacity would enable researchers to clarify the effect of teacher firm characteristics on performance of technology alliance. Thirdly, since universities, research institutions, and foreign firms are not included in the list of the teacher firms, the influence of the total knowledge network has not been considered in this paper. Therefore, the inclusion of cross-border alliances, alliances with government research institutions and universities would enrich the scope and implication for future studies.

Chapter 5. Entry conditions, firm strategies, and their relationships to the innovation performance: The case of the solar cell industry[3]

5.1. Introduction

Growing interest in green technologies as the engine for future growth and new solutions to pollution and energy has been reflected in the number of studies on emerging green industries (Shum and Watanabe, 2007). When potential entrants consider entering emerging industries, fundamental strategic decisions such as "when" and "what scale" have to be tackled (Ayal and Zif, 1979). This brings up critical questions for potential entrants, such as "Do early entrants possess competitive advantage over late entrants?" and "Do large-sized entrants with rich resources have competitive advantage over small-sized entrants once they enter the emerging industry?".

Many studies have been trying to solve these questions, and these efforts have been established as an important research field relating to entry conditions. Research on entry conditions affecting firm performance has been developed as two separate streams of research. One research field aims to

3 An earlier version of this chapter was published in *Asian Journal of Technology Innovation*, 18(2)

explore effects of entry age on firm performance. Since Bain (1956), industrial economists have been interested in how and why entry barriers are built and maintained. A recent important stream of this research field was initiated by Lieberman and Montgomery (1988), who began using the term “first-mover advantage,” and investigated how and why early entrants have relative advantage over late entrants. The second research field involves entry size. Since the emergence of Gibrat’s law, which assumes that firm survival is independent of size, research on entry size has been conducted to determine the true relationship between firm entry size and firm growth (Agarwal and Audretsch, 2001). A large body of evidence suggests that the likelihood of firm growth and survival is not independent of entry size. Specifically, most studies have found that entry size is positively related to firm growth, enhancement of market share, and the likelihood of firm survival (Audretsch, 1991; 1995; Geroski, 1995; Sutton, 1997; Caves, 1998; Agarwal and Audretsch, 2001).

However, although the need for an integrated perspective has been mentioned by researchers such as Kerin, Varadarajan and Peterson (1992), each research area has been independently evolving. A few studies have been focused on the effects of entry age in conjunction with entry size (Mascarenhas, 1997; Rodriguez-Pinto, Gutierrez-Cillan and Rodriguez-Escudero, 2006). Another limitation of previous research on entry conditions is that there is no consideration of firm strategies to enhance performance after entering the market. Moreover, there is a noteworthy lack of empirical studies on the relationship between entry conditions and firm strategies such as,collaborations or technology portfolios. The aforementioned limitations interfere with further applications of theory for practitioners and researchers.

To fill the gaps found in the previous research on entry conditions, this paper examines whether entry age and size have effects on innovation performance, and how firm strategies after market entry strengthen or weaken these effects. The three objectives of this paper are as follows: i) to identify the joint effect of initial entry conditions, such as entry age and entry size on innovation performance; ii) to test moderating effects of entry conditions at the point of entry and firm strategies after market entry on innovation performance; and iii) to devise customized firm strategies aimed to increase innovation performance based on different entry conditions.

This paper conducts empirical research through analysis of data collected from the worldwide solar cell or photovoltaic (PV) industries. With growing interest in the green technology, the solar cell industry has recently gained much attention (Shum and Watanabe, 2007). Many firms are actively involved in the solar cell industry; therefore, information associated with market entry is relatively abundant. Hopefully, results of this paper can help firms that have plans to enter the solar cell market in the near future.

We begin with a review of past research on entry conditions, firm strategies, and their relationships on innovation performance. Based on these reviews, I present eight hypotheses. Next, I discuss the current the solar cell industry and its technological characteristics to help readers understand the industry dynamics and subsequent contribution of this research. Analyses and results from empirical test of the worldwide solar cell manufacturers are then described. Finally, I propose several firm-specific strategies depending on entry conditions.

5.2. Extant literature and hypotheses development

5.2.1. Entry conditions: entry age and entry size

The impact of market entry conditions on firm performance is one of the main research topics in strategic management (Lieberman and Montgomery, 1988; Agarwal and Gort, 1996; Klepper and Simons, 2000; Helfat and Lieberman, 2002). Since the seminal work of Bain in 1956, this research area has gradually received greater attention from both the industry and academia. In recent years, with the growing competency of the enterprises from the developing Asian countries and their expansion into high-tech industries (in particular, semiconductor, display, and mobile industries), the importance of entry conditions has been recognized (Schnaars, 1994; Mathews and Cho, 2000).

Research on entry conditions can be divided into two large research streams. The entry conditions comprise of entry age, which is the point when the firm enters the market, and of entry size, which is the size of the firm at the point of entry. Research stream of "entry age" has been established from Bain (1956), and through Lieberman and Montgomery (1988), who suggested the concept of first-mover advantage. Research stream of "entry size" has been formed by economists, who were stimulated by Gibrat's law.

In many areas of study, such as economics and marketing, previous research on entry age reveals that it has significant impact on the performance of firms and new products (Crawford, 1977; Lieberman and Montgomery, 1988; Robinson, 1988; Lambkin, 1988; Carpenter and Nakamoto, 1990; Agarwal and Gort, 1996; Dutrenit, 2007). Generally speaking, early entrants maintain higher market shares (Robinson and Fornell, 1985; Urban et al., 1986; Lambkin, 1988; Robinson, 1988; Mitchell, 1991; Mascarenhas, 2006) and have higher chances of survival in a market than subsequent entrants (Lambkin and Day, 1989; Mascarenhas, 1997; 2006). This positive performance relationship arises for various reasons. Early entrants have the first choice of locations, employees, agents, and customers. They may be able to obtain inputs at lower market prices than late entrants. Customers may view early entrants as prototypical of the new product category. Early entrants can create and exploit buyer-switching costs, such as contract renegotiation and penalties (Lieberman and Montgomery, 1988). According to these studies, there is a discernible difference in the performance according to the order of entry, and early entrants usually display higher performance than late entrants. A relatively small number of studies have commented on the advantages associated with late entrants (Lilien and Yoon, 1990; Golder and Tellis, 1993; Schnaars, 1994; Shankar, Carpenter and Krishnamurhti, 1998). Entry age is also considered a key factor, and the relevance of this variable is reflected in a large number of papers that have attempted to evaluate the connection of entry age with firm performance.

Entry age is not the only important factor for decision-making when entering new markets. In this research in addition to entry age, another dimension of the entry condition is analyzed: entry size. Previous research on entry size has empirically shown that the size of the firm at the point of entry is not independent of its survival rate, and has indicated that larger size works more favorably to the probability of survival (Geroski, 1995; Sutton, 1997; Caves, 1998; Agarwal and Audertsch, 2001; Rasiah and Gopi, 2008). Sutton (1997) specified that size in the entry year is linked to firm growth in the subsequent time period. Major economic interpretation of the positive relationship between firm entry size and the likelihood of survival builds on the “noisy selection model” introduced by Jovanovic (1982), which was improved upon by Pakes and Ericson (1998). Central implication of the model is that firms may enter at a small, even suboptimal, scale of output and then expand, if merited by subsequent performance (Agarwal and Audertsch, 2001). Successful entrants operating at a suboptimal scale of output will grow, whereas unsuccessful ones will remain small and may ultimately be forced to exit from the industry. Similarly, the greater the entry size in a given industry, the less the cost disadvantage imposed by an inherent size disadvantage, and the greater the likelihood of survival confronting the new entrant.

However, prior research has failed to look at both of these conditions into account, as firms do when making decisions on the entry into new market. Mascarenhas (1997) and Rodriguez-Pinto, Gutierrez-Cillan and Rodriguez-Escudero (2006) agreed with this lackness and suggested the necessity of research jointly investigating entry age and entry size. In this paper, the individual factors (i.e., entry age and entry size) are referred to as entry conditions. Through a joint analysis of both factors, the paper attempts to provide a more integrated view that has been missing in extant research. Based on the above discussion, two hypotheses are suggested.

Hypothesis 1: The older the entry age, the higher the innovation performance.

Hypothesis 2: The larger the entry size, the higher the innovation performance.

5.2.2. Firm strategies: Technology alliance and technology portfolio

Entry conditions measured at the time of entry are not the only factors that explain innovation performance of entrants; therefore, other factors should also be considered. Although many studies have analyzed the effects of entry age and size on performance, other dimensions, such as firm strategies have largely been ignored (Rodriguez-Pinto, Gutierrez-Cillan and Rodriguez-Escudero, 2006). What then, are some of the meaningful strategies for entrants to overcome the disparities in innovation performance arising from different entry conditions?

To answer this question, this paper selects two major strategies as variables, collaborations and technology portfolios, and explores the effects of these strategies on innovation performance. First, collaboration strategy with other firms is a viable option when the firm lacks internal resources. From knowledge-based views and open innovation concepts, each firm has different knowledge and resources that can be used for innovation. Collaboration can help bridge deficiencies. This view suggests that firms possess different knowledge, and collaboration with other organizations provides a channel that facilitates resource allocation. Through collaboration, a firm can absorb a deficient knowledge from partner firms (Leonard-Barton, 1995; Mowery, Oxley and Silverman, 1996). Innovation is constantly required in technology-intensive and early-stage industries, such as in the solar cell industry, because sustaining competitive advantage solely through internal technology and knowledge is difficult. Consequently, exploiting external knowledge through collaboration is especially important in such industries (Gulati, 1998; Chesbrough, 2003; 2005; Teece, 2007).

Although positive effects of collaboration activities have been proven by prior research, some researchers suggest negative aspects of collaboration activities. According to Transaction Cost Economics (TCE), collaborations usually entail higher transaction cost (e.g., negotiating, bidding, and monitoring) than internal R&D activities. Another negative effect is that collaboration processes relatively absorb much managerial time and energy. During collaboration process, attention of top managers and managing functions may be diverted from internal activities (Hitt, Hoskisson and Ireland, 1990). Although the aforementioned negative effects of collaboration strategy are mainly associated with financial and operational aspects, the negative relationship of collaboration with innovation performance and capability of knowledge creation, as covered in this paper, may be difficult to recognize. Therefore, I maintain the view that collaboration strategy has positive effects on innovation performance. Building on these discussions, a hypothesis regarding the contribution of the collaboration activity on innovation performance can be elicited.

Hypothesis 3: After market entry, collaboration activity has a positive

relationship on innovation performance.

Second, Building a technology portfolio of a firm is another important strategy for enhancing performance. When a firm faces technical uncertainty, building a technology portfolio could reduce risks of uncertainty. To clarify the concept of technology portfolio strategy, I review the paper of McGrath (1997), which described and extended the real options theory. This paper posits that real option concept can be explained in terms of “processes,” from technology development to commercialization. Technology portfolio strategy used in this paper could be explained by relating it to the initial stage of real option. According to McGrath (1997), technology portfolio strategy is used in terms of “technology option.” However, I redefine the concept of “technology option” as the “technology portfolio” to obtain a more precise meaning.

Usefulness of a technology portfolio under high technological uncertainty has been suggested by previous research (Trigeorgis, 1993; Dixit and Pindvck, 1994; McGrath, 1997). Dixit and Pindyck (1994) suggested that technical uncertainty highly relates to the likely probabilities of attaining technical success. Although technology uncertainty exists, to secure the benefits (e.g., positive feedback effects of scale, path dependence, and network externality) of leading firms, the firm should invest in new technologies more quickly than competing firms. Technical uncertainties create pressure on the firm to invest immediately. A firm reduces technical uncertainty only through investment in other technologies (Dixit and Pindvck, 1994).

High technological uncertainty also exists in the solar cell industry. According to recent research by Mckinsey and Company (2008), solar cell products made from silicon -based PV technology holds over 90 % of the market. However, there is a technical limit to the efficiency of conversion of energy and competition from thin film PV technology is expected in the near future. Under high technological uncertainty, some solar cell firms are following concurrent development of both silicon-based and thin film technologies (Lorenz, Pinner and Seitz, 2008). As such, building a technology portfolio can be a useful strategy to reduce risk under technology uncertainty (Bowman and Hurry, 1993; Huchzermeier and Loch, 2001; Miller and Arikan, 2004). However, due to the lack of dominant and standard technology, developing various technologies at once disperses the resources and consequently, has negative effect on accumulation of profound technologies. Adopting two technologies with different technology bases is expected to generate less synergy effect.

Absence of accumulation knowledge and synergy effect has negative impacts on improving innovation performance. Evidence for this can be found in previous studies on knowledge learning. Cohen and Levinthal (1990) suggested and defined the concept of "absorptive capacity," and identified two primary factors regarding effective absorption and production of knowledge: accumulations of related prior knowledge and R&D effort. Applying such view on the effect of the technology portfolio on innovation performance, the lack of accumulated prior knowledge and similarity between the technologies indicate that absorption and utilization of external knowledge will be difficult, leading to deterioration of innovation performance. From the resource-based view, failing to allocate tangible and intangible resources will result in dispersed R&D activities. Therefore, with the absence of dominant technology in the early stage of technology-intensive industry, building a technology portfolio is not expected to bring about a positive effect on innovation performance.

Hypothesis 4: After market entry, building a technology portfolio has a negative relationship on innovation performance.

5.2.3. Interactions between entry conditions and firm strategies

Previously I examined literature on the impact of entry conditions and firm strategies on innovation performance. However, asserting that the performance of a firm is absolutely dependent on entry conditions or firm strategies would be unrealistic. As evidenced by Visa Card, Reebok, Google, and Samsung, there are cases in which late and small-sized entrants have outperformed early and large-sized entrants. Some scholars have proven that early entrants do not always hold advantage over late entrants (Cooper, 1979; Schnaars, 1994; Golder and Tellis, 1992). Related research has revealed that early entrants are expected to show sound innovation performance following relatively rapid accumulation of knowledge and technology.

However, there are downsides such as formation of inertia, to the stand-alone internal research over a long period (Lieberman and Montgomery, 1988). Kerin, Varadarajan and Peterson (1992) showed that the effect of entry age is difficult to measure, as its relations to performance are affected by the size of market, strategies of the firm, the industry characteristics, and others. Similarly, the effect of entry age can be offset by rich resources or high internal capacity, according to the research by Moore, Boulding and Goodstein (1991). As for entry size, even small- and medium-sized firms with relatively few resources can promote innovation performance through utilization of external resources, which are becoming increasingly diverse (Timmons, 1999). In summary, the effects of entry conditions are relatively dependent on various factors. In particular, the result of Kerin, Varadarajan and Peterson (1992) indicates that firm strategies set after entrance may alter the effect of entry conditions. Effects of entry conditions on firm innovation performance are better explained using a contingency approach in order to account for the moderating effects of firm strategies, such as collaboration and technology portfolio. Therefore, in this paper, the following hypotheses to verify the moderating effects are drawn from the above discussion.

Hypothesis 5: The effect of entry age on innovation performance varies depending on collaboration activity.

Hypothesis 6: The effect of entry age on innovation performance varies depending on building a technology portfolio.

Hypothesis 7: The effect of entry size on innovation performance varies depending on collaboration activity.

Hypothesis 8: The effect of entry size on innovation performance varies depending on building a technology portfolio.

In the next section, I describe the solar cell industry used for the empirical test. I explore questions related to entry conditions, firm strategies, and their relationships by examining entry cases in the solar cell industry. To understand what a solar cell is, why the solar cell industry has entry issues, and what technology is used in manufacturing solar cell, background knowledge on the solar cell industry will be presented in the next chapter.

5.3.The solar cell industry

5. 3. 1. Emergence of the solar cell industry

As energy resources and global environment issues emerge domestically and abroad, the importance of carbon-saving renewable energy, such as solar cell, is increasing. Unified statistical data or prospect is not available at present as the solar cell industry is still in its infant stage. The survey on installed capacity shows discrepancies of 3.4–5.5 GW (gigawatt) among institutions with inconsistent prospect on the long-term market growth rate. However, the solar cell industry is anticipated to grow by over 50 % in 2009 compared to the previous year. By 2010 and 2011, the demand is expected to sharply grow in most nations. From a long-term perspective, the industry and the technology are still in their early stages and the market size will grow to nearly 2000% by 2020 (Shum and Watanabe, 2007; Lorenz, Pinner and Seitz, 2008).

A solar cell is essentially a photodiode, or a type of semiconductor device. Two fundamental technologies exist for manufacturing solar PV modules: crystalline silicon (x-Si), currently used in 90% of all solar PV modules manufacture, and the next generation thin film modules. In general, cells are built on either silicon or, in the case of thin film technology, glass (most commonly), plastic, or steel. Figure 5-1 shows a basic process flow schematic for silicon-based solar PV systems. In the case of a thin film module, the process up to the module level is different; however, it is similar from the module through the system level.

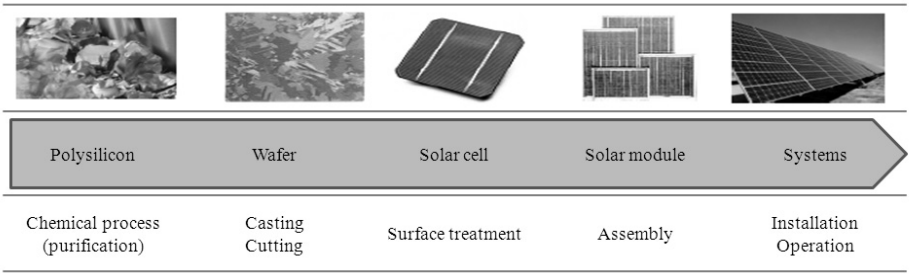

Figure 5-1 Process flow for sillicon-based solar PV installation

Cells are assembled into modules (or panels), which are in turn assembled into an array (or system). The degree of vertical integration varies across the industry. Some firms only produce cells. Others produce cells, assemble them into modules, and install them at the customer site. Other players specialize in simply installing PV systems. The overall supply chain is heavily concentrated in Germany (due to the long-standing government subsidies), and to a lesser degree, Japan and the US (Shum and Watanabe, 2007). Among cell and module makers, China has the heaviest concentration due to significant recent investment and relatively little barriers to entry, whereas Taiwan and Korea, albeit major forces in the semiconductor industry today, remain relatively small players in the solar cell industry.

5. 3. 2. Specification of solar technology

Through the PV effect, sunlight is converted into electricity. When light hits a PV cell, it can be refracted, absorbed, or allowed to pass. Only the absorbed light generates electricity. The energy of absorbed light is transferred to electrons in the PV cell. Therefore, improvements in the solar energy conversion efficiencies are important factors for commercial diffusion. According to Citigroup (2008), silicon-wafer-based PV products display the highest efficiencies and accounts for approximately 95% of total cell production today. Several types of materials can be used for wafer-based PV; however, silicon is by far the most common. Two layers are juxtaposed: one with an abundance of electrons (which carry negative charge) and the other with an abundance of “holes” or vacancies where there would normally be an electron (this carries a positive charge). Sandwiching these together creates an electrical field that acts as a “diode,” allowing electrons to flow from one side to the other, but not the other way around.

When energy from sunlight in the form of photons, hits this cell, the energy frees electron-hole pairs and further creates an imbalance of electrons and holes. An external current path allows the electrons to flow through and back into their original side, refilling the holes. A cell is encapsulated with a number of other materials, including an antireflective coating (silicon is a shiny material and would otherwise reflect many of the photons and prevent them from being converted into usable energy). There are also contact grids on the back and, in most cases, on the front side, as well as a cover glass plate.

Silicon-wafer-based PV typically has better conversion efficiencies; however, given the high cost of polysilicon, it can be costly. Due to key material shortages such as polysilicon, there is a growing need to directly build diodes using various semiconductor materials on a substrate, such as glass or steel. This is called “thin film” PV, which accounts for approximately 5% of worldwide PV cell production today. Whereas the traditional crystalline silicon cell is 165–180 um thick, a thin film layer is only 2–3 um thick. Theoretically, thin film solar cells consume only 1% of silicon consumed by the existing solar cells, leading to a significant cost reduction. In addition, the price of the latest thin film silicon solar cell is said to be merely 30% of its counterpart. Although different semiconductor materials are being explored, the most commercial types include amorphous silicon (a-Si), Cadmium Telluride (CaTe, commercialized most successfully by First Solar), Copper Indium Selenide (CIS), and related materials (CIGS).

5. 3. 3. Increasing competition in the solar cell industry

Japanese enterprises such as Sharp, Kyocera, and Mitsubishi have dominated the solar cell industry until recently. With the increasing attention on green technology, enterprises from other nations are gaining increasingly larger shares of the global solar cell market. Supported by government policies and invigoration of their domestic market, Germany, China, and Taiwan have shown noticeable progress in the solar cell market. The competition is expected to further intensify with the recent announcements of participation plans by other global enterprises (Samsung, LG Electronics, and Hyundai Heavy Industries). With the escalation of competition in the solar cell industry, both early and late entrants are seeking to strategically reinforce their competitiveness for the future. Some have increased their investment on thin film and next-generation solar cell technologies, whereas others have strengthened ties with other firms or expanded either up or down stream.

5.4. Methods

5. 4. 1. Data and sample

As previously mentioned, this paper focuses on the solar cell industry, which has exhibited rapid growth. The solar cell industry has been noted as the next-generation growth momentum addressing global environmental problems and the issue of energy dependency of nations (Shum and Watanabe, 2007). Technological uncertainty is prevalent in the industry, with the absence of dominant and standard technology (Lorenz, Pinner, and Seitz, 2008).

Incumbent firms from electronics, energy, and other heavy industries have announced their plans on future involvement, with other firms following this trend. Therefore, data collection for testing entry matters is comparatively straightforward, provided vigorous entrance and various entry conditions are present. The industry data is appropriate in evaluating the mutual interactions between entry conditions and strategies of individual firms, as firms display high variation in its technology portfolio.

The database was collected in two steps. First, I used the Thomsonone database for brokerage reports and searched PV-related news and articles to extract a list of 73 solar cell manufacturing global firms. Of the 73 selected, 11 were American, 18 European, 8 Japanese, 12 Chinese, 7 Taiwan, and 17 firms were from India, Korea, and other regions.

Table 5-1. Solar cell firms by regions

US	EU	JP	CH	TW	ROW	Total
11	18	8	12	7	17	73

Unlike the semiconductor industry, an independent category for the solar cell industry has not been formed in most of the databases. To extract firms focused primarily on solar cell manufacturing, I excluded firms providing silicon, ingot, installation, and services in the supply chain. Such exclusion was accounted for by the fact that incumbents in silicon or ingot industries, which have been supplying the semiconductor industries, may easily convert their destination of supply, resulting in ambiguous entry points. As for installation and service firms, the low requirement on innovation renders them inappropriate for the current research. Financial data from DataStream and patent data from US Patent and Trademark Office (USPTO) were used for the listed firms.

5.4.2. Dependent variable

To measure the dependent variable, innovation performance, the total number of patents applied in 2008 was used. Previous empirical studies on market entry have focused on financial success or survival of a firm (Crawford, 1977; Lieberman and Montgomery, 1988; Robinson, 1988; Lambkin, 1988; Lilien and Yoon, 1990; Geroski, 1995; Sutton, 1997; Caves, 1998). This paper uses technological success or innovation as proxy for firm performance variable.

In emerging markets such as solar cell, empirical analysis using financial data is difficult owing to a lack of accumulated data. Another factor that invalidates financial data as proxy is internal capacity such as the technological capacity of the industry, which is not accurately reflected in the financial data. The validity of the technological capacity of the industry is compromised because extensions of the facilities are planned and supported by governments. The solar cell industry displays high technology-intensive features, and improvements in energy conversion efficiency are crucial. Therefore, technological success is a vital factor, as supported by Hagedoorn (1993) and Agarwal (1998), who illustrated that there is a strong propensity to focus on producing knowledge during the initial stage of technology-intensive industries to attain competitive advantage. The development of innovative capability is vital for the growth of firms in technology-intensive industries (Agarwal, 1998). Therefore, using technology innovation as the proxy for firm performance is appropriate in the solar cell industry.

5.4.3. Independent and control variables

The entry age in Hypothesis 1 is measured by the number of years from the year when the first revenue is realized until 2008. For most of the cases, the point of first revenue realization differs from the alleged point of entry announced by firms in practice. Therefore, the first point of revenue realization was used to measure entry age for consistency. To measure the entry size in Hypothesis 2, the number of employees at the point of first revenue realization was used. The patent data from USPTO was used to check collaborations and building technology portfolios, as well as the innovation performance. Collaboration strategy in Hypothesis 3 was marked “1” if a firm has co-assigned patents and “0” otherwise. Co-assigned patent applications are typically considered outputs of R&D collaboration. Consequently, the presence of co-assigned patents can be used as a proxy of collaboration strategy. The technology portfolio in Hypothesis 4 was checked by inspecting the types of technologies in the patents (including patent applied). If there are more than two technology types related to the solar cell, the value of technology portfolios was assigned as “1.” In contrast, if the firm focuses on one kind of technology, the value of technology portfolios was measured as “0.” For example, a mark of “1” means that a firm holds both silicon- and thin film-based technologies. In addition, considering the variables of collaborations and technology portfolios as the firm’s activities after market entry, firm strategy variables were measured with patent data from the year following entry. I also assumed a one-year time lag between firm strategies and innovation performance. Hypotheses 5 to 8 tested the relationships between entry conditions and firm strategies. The interaction (moderating) effects between entry conditions and firm strategies were analyzed according to the four modes of interaction variables, which can be measured by multiplying two variables from entry conditions and two variables from firm strategies. Table 5-2 provides a summary of variables with corresponding measurement.

Table 5-2. Variable information and measurement

Variable information					Measurement
Independent variable	Entry condition	H1	Entry age	AGE	Post entry active period until 2008, AGE=2008-year at entry
		H2	Entry size	SIZE	Total number of employment at the point of entry
	Firm strategy	H3	Technology alliance	COLL	1 if co-assigned patent has been applied through R&D collaboration, 0 otherwise
		H4	Technology portfolio	TECH	1 if holding patents based on other technologies, 0 otherwise (e.g., 1 if holding both silicon- and thin film-based technologies, 0 otherwise)
	Interaction effect	H5		AGE*COLL	Entry condition variable times firm strategy variable
		H6		AGE*TECH	
		H7		SIZE*COLL	
		H8		SIZE*TECH	
Dependent variable	Innovation performance			INNO	Number of granted patents in year 2008
Control variable	Specialized firm			SPEC	1 if firm only specialize in solar cell products, 0 otherwise

5.4.4. Empirical method specification

In this paper, the number of patents was used as the dependent variable. The patent application is a discrete event having a positive integer. The likelihood of error is high for such variables if multiple regression analysis is used based on standard distribution assumptions. Poisson regression or negative binomial regression based on discrete distribution is more appropriate. Table 5-3 shows the result of descriptive statistic and correlations. The average of the dependent variable innovation performance (INNO) is 5.88, with its standard deviation reaching 10.21, which violates the basic assumption of Poisson distribution that the average and the distribution are identical. Therefore, the negative binomial regression was used for analysis.

5. 5. Results

Results of the analysis are presented in Table 5-4. The value of AGE variable (representing the entry age) has significantly positive value. Thus, Hypothesis 1 is supported. Older entry age yields better innovation performance. The solar cell industry displays high technology-intensive characteristics, and is currently in between the initial and growth stage. Firms in industries with such characteristics vie with one another for competitive advantage (Agarwal, 1998). Under such circumstances, early entrants have had relatively longer period to accumulate technological capacity, and this in turn, is followed by the enhancement in the innovation based on prior technological knowledge and expertise. As the result of Hypothesis 1, the first mover advantage exists in this industry.

The SIZE variable, representing entry size, shows no statistical significance. Consequently, Hypothesis 2 is rejected. Such results imply that the amount of resources at the point of entry does not affect the innovation performance, a dubious result from the resource-based view. This can be accounted for by the peculiarity of early markets in technology-intensive industries, as addressed by Agarwal and Audersch (2001). The study has empirically shown that the survival rate is less affected by the entry size in high-tech industries than in low-tech industries. Based on the results of Hypotheses 1 and 2, early entrance favors innovation performance, whereas firm size during entry is irrelevant. Therefore, firms planning to enter the industry should start investing at the earliest possible moment, although the investment may be small in size, to accumulate relevant knowledge and technology. The result can also be interpreted for the large firms as well. Even for firms with rich internal resources, rapid entry, rather than taking time to accumulate large resources, is advisable for the enhancement of innovation

Table 5-3. Descriptive statistics and correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Mean	Std dev.
(1) AGE	1.000								9.34	8.79
(2) SIZE	0.724	1.000							10.03	24.13
(3) COLL	0.657	0.499	1.000						0.55	0.50
(4) TECH	0.734	0.594	0.664	1.000					0.41	0.50
(5) AGE*COLL	0.979	0.721	0.782	0.763	1.000				5.06	9.44
(6) AGE*TECH	0.974	0.736	0.663	0.842	0.667	1.000			4.42	9.53
(7) SIZE*COLL	0.725	0.692	0.501	0.596	0.723	0.737	1.000		6.94	2.09
(8) SIZE*TECH	0.725	0.701	0.501	0.596	0.722	0.737	0.328	1.000	7.07	21.12
INNO									5.88	10.21

Table 5-4. Result of Negative binomial regression analysis

Models variables	Model 1		Model 2		Model 3		Model 4	
	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E
AGE	0.162***	0.039	0.474*	0.361	0.157***	0.033	0.698*	0.409
SIZE	-0.001	0.000	-0.001*	0.000	0.000	0.003	0.004	0.004
COLL	1.820***	0.624	5.436**	2.431	2.918***	1.208	9.244***	3.443
TECH	-2.049**	0.828	-3.986***	1.394	-3.021***	1.179	-5.506***	1.600
AGE*COLL			-0.593*	0.392			-0.882**	0.423
AGE*TECH			0.285**	0.157			0.342***	0.110
SIZE*COLL					-0.037	0.047	-0.047	0.067
SIZE*TECH					0.036	0.046	0.042	0.066
SPEC	0.841*	0.525	0.811*	0.501	0.875*	0.498	0.841**	0.340
Log likelihood	-48.286		-46.466		-44.901		-40.246	
Pseudo R^2	0.189		0.219		0.245		0.324	
LR Chi^2	22.44		26.08		29.21		38.51	

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

The COLL variable, representing collaboration strategy, statistically shows positive value at significant level, supporting Hypothesis 3. Firms in the emerging market either make internal efforts to attain distinguished technology or collaborate with other firms to make the most out of their capacity and resources. Given the volatile nature of technology in the solar cell industry, attaining competitive advantage solely through internal knowledge, resources, and capacity is difficult. Therefore collaboration, transfer, and sharing of knowledge with other firms can benefit firms in technology-intensive industries, such as the solar cell industry, by promoting innovation performance.

The TECH variable, representing a technology portfolio strategy, displays negative value at significant level, indicating that Hypothesis 4 is supported. The implication is, rather than building a technology portfolio containing both of the two primary technological branches in the solar cell industry, focusing resources and capacity on one single technology would be more advantageous. With the absence of standards for technology, diversification may help reduce the risk. However, diversifying the capacity by investing on various technologies in the industry has negative influence on innovation performance.

The variable measuring interaction between AGE and COLL in the negative binomial regression analysis displays negative value at the significant level. This indicates that COLL has negative moderating effect on innovation performance with AGE, supporting Hypothesis 5. This result demonstrates that a firm with large value of AGE (i.e., an early entrant) is bound to be under negative influence if it collaborates with others. There is the benefit of reducing risk by collaborations; however, the firm is exposed to leakage of knowledge and opportunistic behavior by the partner. Early entrants usually have accumulated knowledge and thus possess higher technological capacity. Therefore, the likelihood of the early entrants suffering from opportunistic behavior by the partner firm is high. The likely loss of technology appropriability following the leakage of technology is greater than the benefit.

The interaction variable for AGE and TECH has positive value at the statistically significant level. This indicates that TECH has positive moderating effect on AGE and innovation performance. With the accumulated technology and expertise, early entrants are likely to possess dispensable resources for technology diversification. Diversification with the available resources would help enhance innovation performance. This is consistent with the balance of exploration and exploitation from March (1991). Inertia may appear in firms that exploit one specific technology over a long period of time, restricting firms from shrewdly addressing the change in technology and new possibilities. Proper level of exploration on new technology provides variety and flexibility to the firm. With the interaction variable showing statistically significant level, Hypothesis 6 is supported. Table 5-5 summarizes the results of the hypotheses.

Table 5-5. Summary of the hypotheses and results

		Hypotheses	Test results
Entry condition	H1	The older the entry age, the higher the innovation performance	Supported
	H2	The larger the entry size, the higher the innovation performance	Not supported
Firm strategy	H3	After market entry, collaboration activity has a positive relationship on innovation performance	Supported
	H4	After market entry, building a technology portfolio has a negative relationship on innovation performance	Supported
Interaction between entry condition and firm strategy	H5	The effect of entry age on innovation performance varies depending on collaboration activity	Supported
	H6	The effect of entry age on innovation performance varies depending on building a technology portfolio	Supported
	H7	The effect of entry size on innovation performance varies depending on collaboration activity	Not supported
	H8	The effect of entry size on innovation performance varies depending on building a technology portfolio	Not supported

5.6. Discussion

This paper has examined entry conditions, firm strategies, and their relationships using the emerging solar cell industry, which has recently gained much attention. I have examined the impact of entry conditions and firm strategies on innovation performance. Furthermore, I have examined the interactions between conditions and strategies, as well as their combined effects on innovation performance. This study has three major contributions. First, it contributes to personalized strategy planning to firms. Whereas previous literature has provided insights into entry age and size separately, this research provides firms with a more integrated view of entry age and entry size. Second, the study analyzes both dynamic and static factors on the impact of entry condition. Lieberman and Montgomery (1988), Helfat and Lieberman (2002), and other researchers provided important insights on the impact of entry problem on the innovation performance of firms. In practice, however, the impacts of entry conditions are adjusted by the firm strategies, which subsequently follow them (Kerin, Varadarajan and Peterson, 1992; Timmons, 1999). This paper provides empirical evidences of such view. Finally, this paper provides empirical analysis and strategic significance on an industry that, comparatively, has been less studied.

To sum up, in emerging industries such as the solar cell industry, entry age has significant influence on innovation performance, whereas size at the point of entry provides little relevance. The result has implications on investment decision making of real option strategy. For example, firms that appropriate real option strategy invest in various technology and products to reduce technology uncertainties, and then select and focus based on the feasibility of realization and profitability. As firms are faced with limited resources, they experience difficulty in deciding the point of investment time and its size. The result of this paper indicates that the initial size of the investment is rather irrelevant to the innovation performance. Firms considering entry into emerging technology-intensive industries should invest at the earliest possible moment to exploit the advantage of early entry, however small the investment may be.

Strategies planned and executed by firms after entry have significant effect on innovation performance. Building a technology portfolio has been shown to have a negative impact on innovation performance. However, the analyses on the interactions of entry conditions and firm strategies show that the effects of firm strategies differ according to entry age. For early entrants, the benefit of collaboration on innovation performance appears to be low, as well as the risks from building technology portfolios. In contrast, collaborations have a positive effect for late entrants; however, technology portfolios have a negative effect. To enhance innovation performance, empirical research suggests that an early entrant firm should restrain itself from collaborating while building technology portfolio to reduce risk. A late entrant firm should aggressively utilize collaboration strategy while restraining itself from diversifying its resources.

Chapter 6. The impact of competition among partners and focal firm's technological status on future alliance formation in alliance portfolio

6.1. Introduction

Alliances are advantageous for firms because they allow access to partners' knowledge, and diversify risk under the condition of uncertainty. Alliances have proved to be famous and important strategic tool in many different industries (Contractor and Lorange, 2002; Hagedoorn, 1993). Recently, most firms pursue growth by forming alliances with various partners (Lavie, 2007). Thus, alliance portfolio network (henceforth alliance portfolio), constituted by focal firm and various partners, has become the subject of effective operation and management for firms in practice. Accordingly, researchers on strategic alliance and organizational relationship focus on alliance portfolio relative to focal firm and conduct a more in-depth research (Wassmer, 2010).

The number of alliance portfolio research is increasing; however, only limited insights on "competitive embeddedness" in the alliance portfolio are currently explored (Gimeno, 2004; Silverman and Baum, 2002; Trapido, 2007). Competitive embeddedness means embeddeness derived from various competitions in the network of alliance portfolio. The effect of competition on a focal firm within a single alliance attracts many researchers in traditional alliance research (Bleeke and Ernst, 1991; Gomes–Casseres, 1997; Harbison and Pekar, 1998; Park and Russo, 1996). In contrast, researchers have not paid sufficient attention to competition within alliance portfolio (Wassmer, 2010). Two main reasons why researchers put more emphasis on traditional single alliance than on competition within alliance portfolio are as follows. First, relationships within alliance portfolio are complex. Thus, competitive relations are hard to measure. Second, previous literature on alliance portfolio focuses on network structure. Naturally, the research stream in this field shuns competitive relation topic within the structure. Only a few researchers have analyzed the effect of competitive relations within the alliance portfolio on a focal firm. Gimeno (2004) suggests indirect competitive relations within alliance portfolio, and Silverman and Baum (2002) point out the effect of the alliance portfolio of rival firms on a focal firm. However, the amount of research is insufficient to analyze the effect of competition within the alliance portfolio on a focal firm. Thus, the current study focuses on the effect of competitive relations among partners on a focal firm. This research will contribute to understanding competitive embeddedness within alliance portfolio.

Question such as, “How do competitive relations among partners affect focal firm within alliance portfolio?” might be addressed by the case of network business division of LG Electronics. LG Electronics is a subsidiary of

LG Group, one of the largest Korean conglomerates and operated network equipment division in the 1990s and 2000s. The network equipment division of LG Electronics allied with major Korean telecommunication firms, such as SK Telecom and KTF, to provide products and carry out joint R&D programs. Afterward, LG Group spurred telecommunication business through LG Telecom, which led to the alliance between LG Electronics and LG Telecom. LG Electronics supplied network equipment specialized for LG Telecom. Henceforth, SK Telecom and KTF worried that their technological skill and expertise would spill over to their competitor, LG Telecom through LG Electronics. Thus, SK Telecom and KTF finally terminated their alliance with LG Electronics. As a result, the network equipment division of LG Electronics was badly damaged in terms of sales volume because they lost their major customers. Consequently, the network equipment division was transferred to LG–Nortel as LG Electronics restructured their businesses. As shown in this case, focal firm have relationships with various partners within the alliance portfolio. The competitive relations among partners can greatly affect the focal firm's performance and activities. Among various effects of competitive embeddedness within alliance portfolio, the present study focuses on the effect of competitive relations among partners on focal firm. Competitive relation management is also discussed.

Specifically, the current research has two purposes: to determine the effect of competitive relations among partner firms within the focal firm's alliance portfolio on the focal firm's subsequent alliance formation, and to clarify the capability that effectively helps manage competitive relations among partner firms in terms of the focal firm. For an empirical test, 2,539 technology alliance cases between pharmaceutical-biotechnology firms are collected. Moreover, financial and patent information of each focal firm is combined to constitute the data set. The said data set is then analyzed using ordinary negative binomial regression and zero-inflated negative binomial regression. This method is used due to the characteristic of the dataset, which will be mentioned in later discussions.

The current study consists of four different sections. First, previous research on alliance portfolio is reviewed to establish the logical background of relationships between competitive embeddedness and new alliance formation. Additionally, the moderating effect of technological status on new alliance formation is investigated. These relationships and the effect are hypothesized. Second, samples, variables, and regression analysis are described under methodology. The third section presents the results. The final section provides the discussion and conclusion.

6.2. Theoretical background and hypotheses

6.2.1. Traditional alliance and alliance portfolio

Researchers have not achieved consensus on the definition of alliance portfolio (Lavie, 2007). According to the review paper of Wassmer (2010), alliance portfolio can be categorized into three different definitions. First, alliance portfolio clusters direct ties of all simultaneous alliances (Baum and Silverman, 2004; George, Zahra, Wheatley and Khan, 2001; Hoffmann, 2005, 2007; Jonghoon and Gargiulo, 2004; Lavie, 2007; Lavie and Miller, 2008; Marino, Strandholm, Steensma and Weaver, 2002). Second, based on previous literature in network theory, alliance portfolio is an egocentric network around a focal firm that contains indirect as well as direct ties compared to the first viewpoint (Baum, Calabrese and Silverman, 2000; Gimeno, 2004; Ozcan and Eisenhardt, 2009; Rowley, Behrens and Krackhardt, 2000; Tsai, 2002). Finally, based on organizational learning literature, alliance portfolio is an accumulated alliance relationship, which includes past and current alliances (Anand and Khanna, 2000; Hoang and Rothaermel, 2005; Kale, Dyer and Singh, 2002). Likewise, researchers have different definitions of alliance portfolio. The current study aims to guide field managers in forming and managing alliance portfolio. Therefore, the focus is not on indirect ties or past alliance, but on direct and simultaneous current ties to define alliance portfolio network. Accordingly, the first definition of alliance portfolio is adopted. The said definition involves all simultaneous direct ties solely.

Traditional alliance research focuses on single alliances, whereas alliance portfolio research focuses on multiple alliance partners that constitute the egocentric network of focal firm in terms of analysis level. As the level of analysis has changed, the area of interest has changed as well (Wassmer, 2010). Traditional alliance research mainly tackles formation, governance, evolution, and performance of alliance (Gulati, 1998). On the contrary, alliance portfolio research attempts to uncover the issues of emergence, configuration, and management of multiple simultaneous alliances with different partners (Wassmer, 2010). Additionally, alliance portfolio network has diversified theoretical lenses, such as social network theory (Ahuja, 2000; Goerzen, 2007; Jonghoon and Gargiulo, 2004), organizational learning (Hoang and Rothaermel, 2005; Lavie and Miller, 2008), and resource-based view (Lavie, 2006; Zaheer and Bell, 2005).

The configuration of alliance portfolio network has been actively investigated. Researchers such as Ahuja (2000), Deeds and Hill (1996), and Shan, Walker and Kogut (1994) have analyzed the effect of alliance portfolio size on focal firm's performance. Shat et al. (1994) suggest that the number of partners linked with a focal firm has a direct linear effect on the focal firm's performance, and others show a curvilinear effect (Deeds and Hill, 1996; Hagedoorn and Frankort, 2008). A moderated relationship between the number of direct indirect ties has also been suggested (Ahuja, 2000). In addition, the effect of alliance partners' characteristics on the focal firm's performance has also been the subject of several studies (Baum et al., 2000; Lavie, 2007; Stuart, 2000). Stuart (2000), in his research on entrepreneurial firms, indicates that the benefit derived from the alliance portfolio is mostly determined by technological and innovation capabilities as well as the revenue of the focal firm's partners. Lavie (2007) also addresses the issue of contribution derived from the alliance partners' resources to the focal firm's value creation.

Furthermore, Baum et al. (2000) emphasize that the diversities of alliance partners increase the performance of the alliance portfolio. Other researchers have expressed an interest in structural and relational characteristics. Capaldo (2007) suggests that a strong dyadic tie with alliance partners has a positive effect on innovation performance. Tiwana (2008) asserts that firms often use a mix of structural holes bridging ties as well as strong ties to enhance alliance ambidexterity and alliance performance on the alliance portfolio level of analysis. Likewise, previous literature on alliance portfolio verifies alliance portfolio size, partner characteristics, and structural variables that affect focal firm's performance. Meanwhile, how competitive relations formed within the alliance portfolio affect the focal firm's performance has not been highlighted.

6.2.2. Competition in single alliance and alliance portfolio

Interest in the effect of competition on the focal firm's alliance formation in the research area on single alliance is well established (Gnyawali and Madhavan, 2001). Gomes–Casseres (1997) contends that firms increasingly tend to cooperate with competitors. Harbison and Pekar (1998) suggest that the alliance between rival firms accounts for 50 percent of new alliances, emphasizing research on alliance relationship among competitors. Corresponding to this research stream, many studies in previous literature analyze the effect of alliance relationship among competitors on the focal firm (Bleeke and Ernst, 1992; Kogut, 1989; Park and Russo, 1996). Empirical evidence of the effectiveness of alliances between direct competitors has generally been negative. Bleeke and Ernst (1992) suggest an alliance success rate of 62% when firms have minimal competitive relations with an alliance partner, whereas a success rate of 25% is suggested when firms have high competitive relations. Kogut (1989) maintains that market share instability (a proxy for rivalry) increases alliance dissolution. On the other hand, Park and Russo (1996) attest that alliances among direct competitors are more likely to fail.

The effect of competitive relations on a focal firm has not been sufficiently examined in the field of alliance portfolio research (Gimeno, 2004; Silverman and Baum, 2002; Vanhaverbeke and Noorderhaven, 2001). To be sure, Silverman and Baum (2002) investigate the effect of competitive pressure of competitor's alliance portfolio on the focal firm, and Gimeno (2004) explores indirect competitive relations that occur by sharing partners with a rival firm. However, only a few researchers have expressed an interest in competition and alliance portfolio at the same time. Except for the two studies mentioned above, that of Vanhaverbeke and Noorderhaven (2001) considers alliance portfolio and competition together by explaining the case of RISC microprocessor industry, in which competition does not occur on a firm level but on a group level.

In the current study, how competitive relations within the alliance portfolio network affect a focal firm and contribute to understanding the complex competitive relations within an alliance portfolio network is tested empirically. Furthermore, the effect of competitive pressure, which occurs by competition between alliance partners constituting the alliance portfolio network, on a focal firm's performance is investigated. The competitive relations between alliance partners highlighted in the present research as the level of analysis is differentiated from those of Silverman and Baum's (2002) competitive pressure and Gimeno's (2004) indirect competitive relations. Silverman and Baum (2002) examine the effect of the size and characteristics of a rival's alliance portfolio on the exit rate of a focal firm. The said researchers' unit of analysis is competitive pressure on a focal firm derived from the direct rival firm's alliance portfolio. Gimeno (2004) addresses the problem derived from sharing partners between focal firm and rival firm. Gimeno's unit of analysis is indirect competitive relation, a linkage between focal firm and rival firm through a focal firm's alliance partner. Figure 6-1 describes the aforementioned competitive relations.

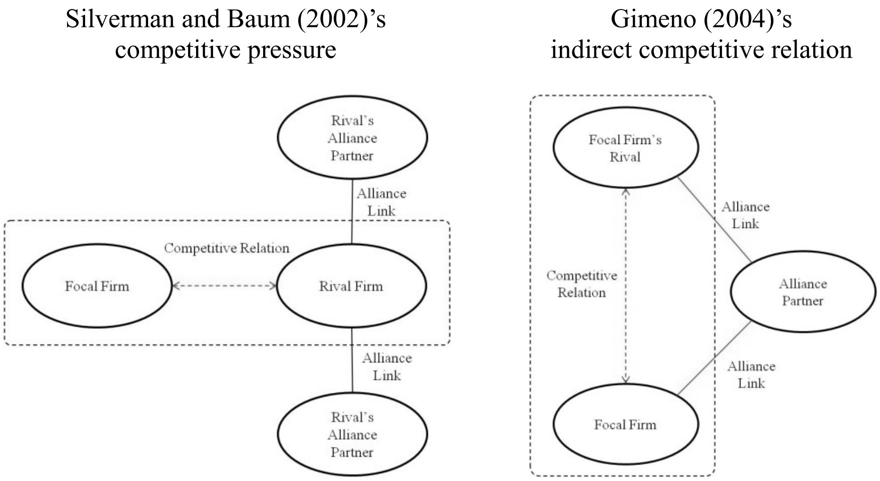

Figure 6-1. Definition of competition on prior alliance portfolio research

The competitive relations among alliance partners that surround and ally with a focal firm and their effect on focal firm are examined in current research. Such a relation is defined as competitive pressure between alliance partners. As defined by previous literature, competitive relation is rivalry between focal firm and the others, and its interest is on the rival firm's direct or indirect effect on a focal firm. The focal firm is perceived as a third party under rivalry among the focal firm's partners.

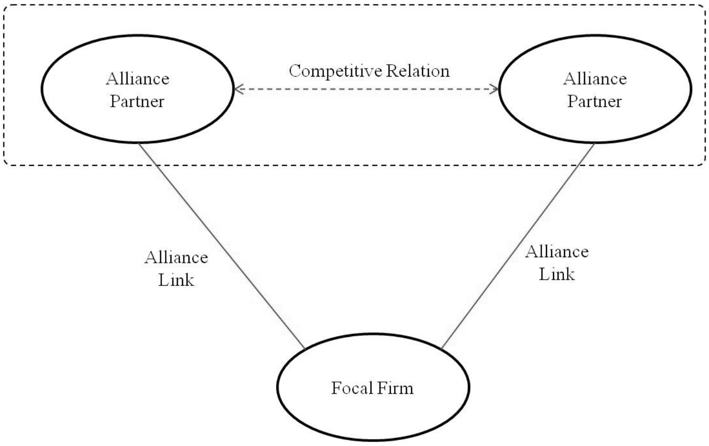

Figure 6-2. Competitive relation among alliance partners

6.2.3. Competitive relation among alliance partners and alliance formation

Network embeddedness theory shows another evidence that indirect competitive pressure derived from alliance partners' competition has an effect on a focal firm (Walker, Kogut and Shan, 1997). Network embeddedness theory has implications, such that firms embedded in the network of cooperative relationships influence the flow of resources among them (Chen, 1996; Gnyawali and Madhavan, 2001). At present, alliances are commonly viewed as elements of an alliance portfolio network. And many researchers theorize and conceptualize the influence of the whole network beyond primary and direct relations, such as indirect ties (partner's partners), network centrality, network autonomy, and so on (Gimeno, 2004; Granovetter, 1985; Uzzi, 1997). Furthermore, recent studies distinguish competitive activities embedded in network, using the term “competitive embeddedness” from network embeddedness (Gimeno, 2004; Gnyawali and Madhavan, 2001). In competitive embeddedness, competitive relations of partner firms do not directly affect a focal firm. However, such a relation influences the alliance portfolio network. Consequently, the focal firm, which is in the middle of alliance portfolio network, is also influenced in terms of its decision making, activities, and performance.

Forming new alliance with new partners has a positive effect on the growth of the focal firm, such that more and diversified channels for absorbing knowledge can be taken advantage of. Moreover, alliance formation is more essential for small and medium enterprises such as biotechnology firms because relevant alliances support them by providing human and physical resources for growth (Stuart, 2003). What effect does competitive embeddedness caused by competition between current alliance partners have on focal firm which can grow through new alliance formation? The current study suggests that competitive embeddedness within the alliance portfolio of focal firms produces negative effects. Three general reasons underpin these new alliance formation difficulties. First, as competitive embeddedness occurs within the alliance portfolio network, focal firms need to put more resources to align goals within the network. Benefits gained from the network, which partners of the focal firm share equally, will not result in competitive asymmetry among them (Park and Ungson, 2001). Accordingly, incumbent partners tend to pursue private benefits through opportunistic behavior and try not to do their best in cooperation under an alliance with the focal firm (Khanna, Gulati and Nohria, 1998). Consequently, focal firms consume enormous human and physical resources to maintain and manage their alliance portfolio and lack of resources, which help in exploring and forming new alliances. Second, incumbent partners of alliance portfolio do not want the focal firm to form more alliances with new partners because of the risk of uncontrolled information disclosure under the situation of competitive embeddedness within the network. Generally, the firm’s technology and knowledge transfer to the other firm directly or indirectly under the alliance formation (Gulati, 1998). In an alliance portfolio, partner firms are concerned about the spillover of their core technology and knowledge to competitors through the focal firm of the network (Emerson, 1962; Pfeffer and Salancik, 1978; Singh and Mitchell, 1996). The risk of spillover increases as the size of the alliance portfolio network becomes bigger. Therefore, incumbent partner firms do not want the focal firm to form new alliances, and the valuable relationship between the focal firm and the incumbent partner might weaken at the same time. This problem has been previously exemplified in the case of the network equipment business of LG Electronics. Finally, the focal firm faces constraints and troubles in bargaining with potential partners that might participate in the focal firm's alliance portfolio network because of competitive embeddedness. More specifically, competitive embeddedness constrains the focal firm in coordinating feasible R&D and business field with potential partners. Such a constraint is derived from exclusive contracts with incumbent partners, at first. However, eventually, competitive embeddedness within alliance portfolio network might create more constraints for the focal firm in forming an alliance with potential partners. In sum, with competitive embeddedness within the alliance portfolio network of a focal firm, the focal firm lacks resource to manage the whole portfolio, faces restraints from incumbent partners, and finally confronts difficulties in contracting with potential partners to form new alliances. Furthermore, the greater competitive embeddedness within alliance portfolio network is, the harsher the three negative factors on new alliance formation become.

Before the influence of competitive embeddedness on new alliance formation is hypothesized, the depth and breadth of competitive embeddedness are distinguished to examine the multi-dimensions of the influence in detail. The depth denotes the intensity of the competition within the alliance portfolio network, and the breadth signifies the scope of the competition within the network. Generally, research in the field of knowledge configuration and knowledge transfer adopts the concept of depth and breadth to understand the ambiguity of knowledge in more detail (Cepeda and Vera, 2007). The concept of breadth and depth is applicable to knowledge configuration because knowledge can be categorized into diversified domains. In addition, specific knowledge can be concentrated within knowledge configuration. Likewise, competition among partners in alliance portfolio can be categorized into various fields and intensified in a certain field according to their business domains.

The operational definition of depth and breadth is as follows. The depth of competitive embeddedness is the absolute level of competitive relation among partners. The competitive relation a focal firm has within its alliance portfolio network is measured. The breadth of competitive embeddedness is the scope of common business fields, or the scope of rivalry among alliance partners. In practice, firms operate a diversified business portfolio, and the scope of rivalry between rival firms varies from case to case. In the current study, the multi-dimensional influence of competitive embeddedness on the focal firms' new alliance formation is tested empirically by distinguishing depth and breadth. Based on the arguments mentioned earlier, the following hypotheses are derived.

Hypothesis 1a: The deeper the competitive embeddedness among partners within the focal firm's alliance portfolio, the worse the focal firm's new alliance formation becomes.

Hypothesis 1b: The broader the competitive embeddedness among partners within focal firm's alliance portfolio, the worse the focal

firm's new alliance formation becomes.

6.2.4. Technological status and competitive embeddedness

What happens if competitive embeddedness has a negative effect on new alliance formation as suggested in Hypothesis 1? What should focal firms do in accordance with this situation? Considering the characteristic of alliance portfolio in which incumbent partners' dynamism due to their entry in new business and M&A, it is difficult for focal firms to fully expect and control competitive embeddedness among alliance partners. The exogenity of competitive embeddedness that focal firms cannot fully control is acknowledged, and the focal firm's technological status, which moderates the negative effect of competitive embeddedness, is suggested.

Focal firms with a high level of technological status can moderate the negative effect of competitive embeddedness because of two reasons. First, a high level of technological status implements a shield role from external restraints, such as the intervention of incumbent partners (Durand et al., 2007; Phillips and Zuckerman, 2001; Podolny, 1993; Rao, 1994). Hsu and Hannan (2005) suggest that the restraint on activities of firms depends on the status of their achievement. Furthermore, Phillips and Zuckerman (2001), through empirical tests on investment banks, demonstrate that firms with a high level of status are pressed with a low level of social restraint in case their behavior goes against goal alignment, compared to firms with a low level of status. This suggestion is adapted to the framework of the present research. Focal firms with high technological status are free from the restraint of partner firms when they disturb the new alliance formation. Second, a high level of technological status reinforces the bargaining power of focal firms. In case of alliance for technological development, focal firm's original knowledge and technology attract potential partners to the alliance. Similarly, Zhang and Baden–Fuller (2010) also suggest that technological base of focal firm promotes alliance formation with partners. Potential partners are likely to accept limited conditions derived from competitive embeddedness within the focal firm's alliance portfolio when they have no other options but to partner with the focal firm. Therefore, the focal firm's high technological status leads to reinforcement of its bargaining power, which ensures an advantageous position in case of new alliance formation. Consequently, the following hypotheses that test the moderate effect of technological status are proposed.

Hypothesis 2a: As the focal firm's technological status becomes higher, the negative effect that the depth of competitive embeddedness among partners has on the focal firm's new alliance formation is moderated.

Hypothesis 2b: As the focal firm's technological status becomes higher, the negative effect that the breadth of competitive embeddedness among

partners has on the focal firm's new alliance formation is moderated.

To describe the above-mentioned hypotheses more clearly, Figure 6-3 shows a diagram that summarizes the research model and hypotheses.

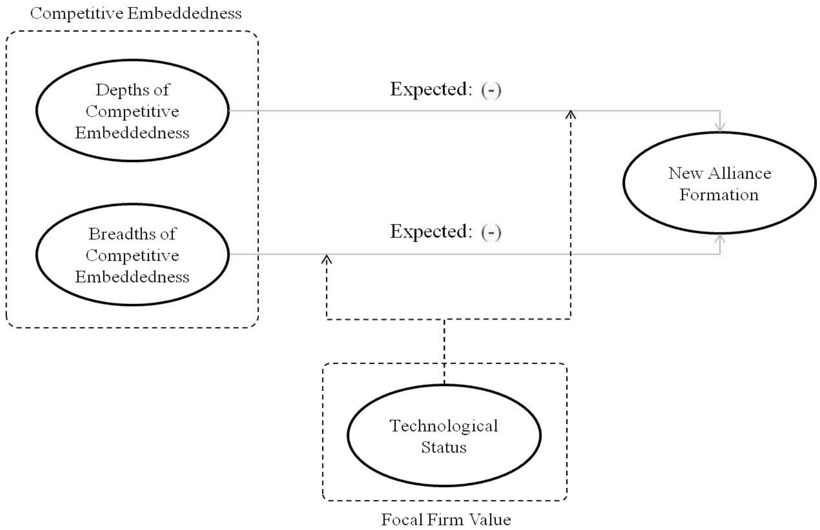

Figure 6-3. Research model conceptualization and hypotheses

6.3. Methods

6.3.1. Data and sample

To test the hypotheses, data from biotechnology-pharmaceutical alliance cases were collected. Collection of data was performed as follows. First, the technology alliance portfolio sample of biotechnology focal firms in the

United States, from 2002 to 2006, was obtained from the Bioscan database. Then, financial information such as sales, number of employees, and size of R&D investment as provided by the Datastream database were added. Finally, patent information provided by the US Patent and Trademark Office were also included. A total of 2,539 technology alliance samples from 159 firms were collected.

The reasons for choosing biotechnology-pharmaceutical alliance cases are as follows. First, the biotechnology industry is a representative high-tech industry, which grows from innovation and chooses technology alliance strategy most actively among all industries (Hagedoorn, 2002). Accordingly, conducting an empirical test for the alliance portfolio built up by incumbent alliance partners and focal firm based on a vast array of alliance data is appropriate. Second, the biotechnology-pharmaceutical industry includes varied sub-sectors according to products, such as cancer, cell therapy, and vaccines. Therefore, the industry facilitates measuring the breadth and depth of competitive embeddedness. Third, a number of prior researchers have chosen the biotechnology industry to carry out alliance portfolio research (Baum et al., 2000; Carayannopoulos and Auster, 2010; De Carolis, 2003; Deeds and Hill, 1996; George et al., 2001; Gulati and Higgins, 2003; Hagedoorn, 2002; Hoang and Rothaermel, 2005; Powell, Koput and Smith-Doerr, 1996; Shan et al., 1994; Vassolo, Anand and Folta, 2004; Zhang, Baden-Fuller and Mangematin, 2007). Finally, precise data are available within a single industry, thus raising the reliability for test results because controlling the industry is unnecessary (Brouthers and Hennart, 2007).

6.3.2. Dependent variable

A dependent variable, *Alliance formation,* is introduced. Alliance formation is the number of total technology alliances made by focal firms from 2005 to 2006. Searching for potential alliance partners and processing the contract take time. Therefore, bias can be reduced, which can be derived from this problem, by counting two years. New alliance formation is set as the performance of focal firms. In the field of alliance research, new alliance formation is used frequently as a performance variable (Gimeno, 2004; Gulati, 1995; 1999). In case of asymmetric technology alliances between biotechnology and pharmaceutical firms, setting alliance formation as a performance variable is more appropriate. Specifically, biotechnology firms specialize in R&D, and receive human and physical assets that aid their R&D and organizational operation from their pharmaceutical partners in certain types of vertical transactions (Stuart, 2003). Accordingly, alliance formation is not just one of strategic choices, but a critical performance for survival for biotechnology focal firms.

6.3.3. Independent variables

The two variables, depth and breadth, are set to measure competitive emeddedness in more detail. To set the variables, the concept of niche overlap, which was used to measure competitive relations in previous literature (Chen, 1996; Gimeno, 2004), is extended. The concept of niche overlap explains that competitive relations exist when firms seek out the same limited resources or target the same markets or customers (McPherson, 1983). Simply, firms in the same industry belong to competitive relations. In previous literature, competitive relations are measured according to the overlap of industrial classification index such as Standard Industrial Classification (Gimeno, 2004; Park and Kang, 2009). In the current study, a firm is assumed to implement multi-businesses, investigate the business domain of each firm, and finally measure the depth and the breadth in the level of business domain. Specifically, the *depth* of competitive embeddedness stands for the absolute level of competitive relations among alliance partners within the focal firm's alliance portfolio; hence, the number of the entire dyadic competitive relations among alliance partners is divided by the number of rival business domains within the network. The *breadth* of competitive embeddedness is the scope of competition; in other words, breadth pertains to the scope of rivalry due to the overlap of business domains among alliance partners within the alliance portfolio network. Breadth is measured by counting the number of business domains that are in competitive relations within the network. The following is an example of measuring *depth* and *breadth*. In 2002 to 2004, Aastrom Biosciences, as a focal firm, allied with Cambrex, Corning and Sanofi Aventis. These three firms thus belong to the alliance portfolio of Aastrom Biosciences. (The business domain of Corning is set arbitrarily for convenience in this example.) In the case of *depth,* Cambrex and Corning are under competitive relations in the field of vaccines. Cambrex and Sanofi Aventis are under competitive relations in the field of cancer. Hence, two competitive relations exist within the alliance portfolio network of Aastrom Biosciences (i.e., in the field of cancer and vaccines). These two competitive relations are divided by two business domains. Therefore, the *depth* of competitive embeddedness within such a network is 2 over 2, or simply 1. The *breadth* of competitive embeddedness within the network is simply the number of the entire domains of rivalry, which is 2. The entire dyadic relations among partners are emphasized in measuring competitive relations for the convenience of calculation in the present study.

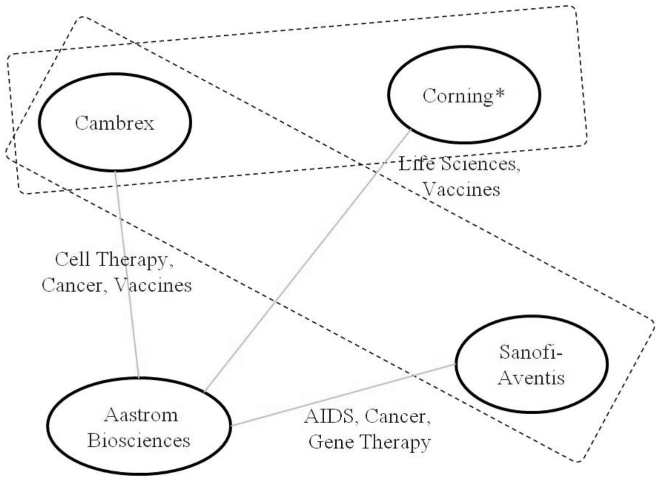

Figure 6-4. Case of Aastrom Biosciences′s alliance portfolio network

In addition, the moderate effect of *technological status* is tested. The method used to measure *technological status* variable is as follows. *Technological status* is measured by counting the accumulated total number of patents applied by each focal firm until 2001, which is right before the period when the depth and the breadth of competitive embeddedness within alliance portfolio of focal firms are measured. Kim et al. (2010), Podolny et al. (1996), and several others measure the qualitative level of firms' patents by calculating the patent citation ratio. However, the method has a disadvantage because it does not include information on the firms' quantitative capability of producing a certain number of patents. In the current study, quantitative patent-producing capability is given priority. *Technological status* is measured by counting the total number of cumulative patents applied for by a focal firm before they form alliances during the years of analysis.

6.3.4. Control variables

Six control variables are used. First, *firm size* measures the sales of focal firms. Considering the cycle of economy, this variable uses the average value of sales from 2002 to 2004. Second, *firm age* measures the number of years from the year when the first revenue is realized until 2002. Park and Kang (2010) have empirically tested the existence of interaction effect between the difference of entry age and the alliance formation. This factor is also included in the control variables. Third, *R&D expenditure* is the focal firm's averaged annual expenditure for R&D from 2002 to 2004. Fourth, *prior M&A experience* is set to 1 (more than one experience) or 0 (no experience). Fifth, *prior manufacturing alliance experience* is set to 1 (more than one experience) or 0 (no experience). Finally, the variable *IPO* stands for whether firms made an initial public offering (IPO) (coded as 1) or not (coded as 0). IPO means listing on the stock market so that a private firm can open its ownership to the public and publicize its financial information. The ownership of firms that made an IPO is decentralized. Thus, these firms are obliged to publicize their information. Moreover, their decision-making processes such as choosing a strategy are likely to be different from those firms that did not make an IPO. Variables, as mentioned earlier, are controlled to increase the reliability of the test results, and verify the pure effect of competition on alliance formation.

6.3.5. Empirical estimation method

In the current study, new alliance formation is treated as a dependent variable. Table 6-1 shows that new alliance formation is a variable for discrete events having a positive integer value. Moreover, this dependent variable shows over-dispersion distribution. Specifically, the variance, 2.97, is greater than the mean, 2.05. In this case, negative binomial regression models provide a standard framework for the analysis of over-dispersed count data (Barron, 1992; Cameron and Trivedi, 1986; Ranger-Moore, Banaszak-Holl and Hannan, 1991). Additionally, the data for dependent variable consist of 63 zeros out of the total 159 values, which is almost 40% of the entire values. The case where a dependent variable acquires many zero-counts induces bias and decreases the reliability of the model. One approach to analyze count data with many zeros is to use a zero-inflated negative binomial distribution (Greene, 1994). To choose the relevant model between a negative binomial and a zero-inflated one, the Vuong test was implemented. The Vuong test compares the zero-inflated model with an ordinary negative binomial regression model. A significant z-test indicates that the zero-inflated model is better (Long, 1997). The result for Vuong test was a p-value of 0.1016. Therefore, the null hypothesis cannot be rejected, supporting the negative binomial model.

However, this result still shows less reliability for choosing one model solely because the p-value is slightly out of range for rejecting the null hypothesis. Consequently, both models were tested using negative binomial and zero-inflated negative binomial to increase the reliability of the present research.

6.4. Results

Table 6-2 presents the results from the negative binomial regression, whereas Table 6-3 shows the results from the zero-inflated negative binomial regression. The two regressions indicate a small difference in significance for some variables, such as *Technological status* and *Depth* × *Technological status*. However, the aforementioned regressions obtain similar results for the direction and magnitude of coefficients, and finally the tests for hypotheses. The analysis of the test results is based on Model 3 of Table 2.

Table 6-1. Descriptive statistics and correlations among the variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	Mean	SD.
Firm size	1.00												2797.20	12762.58
Firm age	0.36	1.00											8.84	5.40
R&D expenditure	0.62	0.44	1.00										321.68	1044.78
M&A experience	0.21	0.06	-0.01	1.00									0.06	0.25
Manufacturing alliance	0.16	0.18	0.10	0.03	1.00								0.22	0.41
IPO	0.07	0.14	0.09	0.00	0.09	1.00							0.81	0.38
Breadth	0.13	0.15	0.37	-0.14	-0.13	-0.02	1.00						1.50	1.52
Depth	-0.01	0.08	-0.02	-0.02	0.11	0.03	0.12	1.00					2.95	8.88
Technological status	0.23	0.30	0.47	-0.05	0.05	0.10	0.23	-0.04	1.00				97.18	320.56
Breadth × Technological status	0.30	0.24	0.58	-0.04	0.07	0.06	0.61	-0.01	0.56	1.00			258.22	1529.14
Depth × Technological status	0.48	0.24	0.32	0.09	0.18	0.07	0.19	0.74	0.16	0.22	1.00		200.38	964.33
Alliance formation	-0.04	0.11	-0.01	0.07	0.22	0.10	-0.17	-0.13	0.38	0.10	-0.07	1.00	2.05	2.97

Table 6-2. Negative binomial regression results for the alliance formation

Depend variable:	Model 1		Model 2		Model 3	
Alliance formation	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
Control variables						
Firm size	-0.0000	0.0000	-0.0000	0.0000	-0.0001**	0.0000
Firm age	0.0298	0.0196	0.0176	0.0181	0.0282	0.0181
R&D expenditure	0.0000	0.0001	0.0000	0.0001	-0.0002	0.0002
M&A experience	0.5528	0.3684	0.5292*	0.3273	0.4245	0.3131
Manufacturing alliance	0.6800***	0.2265	0.7095***	0.2073	0.6271***	0.2062
IPO	0.3375	0.2268	0.2364	0.2453	0.2116	0.2391
Independent variables						
Breadth			-0.1301*	0.0681	-0.2711***	0.0876
Depth			-0.0263*	0.0150	-0.0970***	0.0289
Technological status			0.0009***	0.0002	0.0006**	0.0002
Breadth × Technological status					0.0003***	0.0001
Depth × Technological status					0.0009***	0.0003
N	159		159		159	
Log likelihood	-297.661		-285.023		-277.734	
Pseudo *R*^2	0.0305		0.0716		0.0954	
LR Chi^2	18.70		43.98		58.55	
Regression *p*-value	0.0047		0.0000		0.0000	

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

Table 6-3. Zero-inflated negative binomial regression results for the alliance formation

Depend variable:	Model 4		Model 5		Model 6	
Alliance formation	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
Control variables						
Firm size	-0.0000	0.0000	-0.0000	0.0000	-0.0001**	0.0000
Firm age	0.0279	0.0218	0.0106	0.0185	0.0226	0.0181
R&D expenditure	0.0001	0.0002	0.0001	0.0002	-0.0002	0.0002
M&A experience	0.6013	0.4179	0.5629*	0.3351	0.3693	0.3080
Manufacturing alliance	0.7237***	0.2560	0.7261***	0.2170	0.5521***	0.2132
IPO	0.4205	0.2984	0.3889	0.2547	0.4167*	0.2426
Independent variables						
Breadth			-0.1528**	0.0733	-0.2741***	0.0920
Depth			-0.0167	0.0112	-0.0764***	0.0310
Technological status			0.0009***	0.0003	0.0006***	0.0002
Breadth × Technological status					0.0002***	0.0001
Depth × Technological status					0.0007**	0.0003
N(Zero obs)	159(63)		159(63)		159(63)	
Log likelihood	-290.569		-279.227		-274.467	
LR Chi^2	16.29		38.97		48.49	
Regression *p*-value	0.0123		0.0000		0.0000	
Vuong test *p*-value (*z*)	0.4529 (z=0.12)		0.1066 (z=1.24)		0.1012 (z=1.27)	

Notes: *p < 0.10; **p < 0.05; ***p < 0.01.

First, *Breadth* of competitive embeddedness is negatively correlated to the focal firm's future alliance formation, and this relationship is highly significant ($p<0.01$). This result implies that focal firm's difficulty in forming new partnership increases as the competitive relations among partners of focal firm within its alliance portfolio broaden, that is, under the situation of a great deal of overlapped business domains among partners. The negative effects of competitive embeddedness on focal firm are summarized as follows: depleting the resources of the focal firm for managing partners; restraint of incumbent partners; and anxiety of potential partners earlier in the theory development part. The analysis for results based on these three effects is as follows. In terms of the focal firm's resources, the broad domain of competition among the focal firm's partners implies that the focal firm forms alliances in varied business domains. Among the negative effects of competitive embeddedness on focal firm's subsequent alliance formation mentioned earlier, broad competition among partners is mainly related to the depletion of the focal firm's resources and the anxiety of potential partners. The negative effect on the depletion of the focal firm's resources is as follows. The focal firm should put an enormous amount of human and physical resources to maintain relationships with a broad type of incumbent partners. However, the focal firm does not have sufficient resources to search for potential alliance partners. The negative effect on anxiety of potential partners is as follows. When the focal firm succeeds in searching potential alliance partners and proceeds with the contract, the focal firm might encounter difficulty in forming an alliance because of increased constraint derived from potential partners' anxiety. From the potential partner firms' viewpoint, choosing the focal firm as an alliance partner can lead to spillover for their knowhow and knowledge spillover to their competitors who are already partners with the focal firm. Potential partners would claim a great deal of constraint, which restricts the scope for cooperation through secrecy agreement, interchange of personnel, and so on, to relieve the risk of spillover. Consequently, such a constraint generates cost to the focal firm and potential partners in the negotiation procedure. Specifically, this conflict would be more sensitive in the biotechnology-pharmaceutical industry where technology-intensive knowledge leads to competitive advantage.

The second independent variable, *Depth* of competitive embeddedness, also has a negative relationship with the focal firm's future alliance, and this relationship is highly significant ($p<0.01$). This result implies that the focal firm's partners, who are concentrated on specific business domains and on competing with one another, have a negative effect on the focal firm's future alliance formation. Among the negative effects of competitive embeddedness on the focal firm's subsequent alliance formation mentioned earlier, broad competition among partners is mainly related to the restraint of incumbent partners. Competition among partners in specific business domains implies a high risk of knowledge spillover among competitive partners through the focal firm. Consequently, incumbent partners tend to intervene intensively in the focal firm's alliance management to maintain their advantage in the alliance with the focal firm. The case of LG Electronics mentioned earlier is a relevant example. LG Electronics formed an alliance with LG Telecom against the will of their incumbent partners, and accordingly lost incumbent partners, SK Telecom and KTF. LG Electronics sold their network equipment division finally due to the loss of valuable partners. In sum, incumbent partners intensify or even give up the current alliance contract to restrain knowledge spillover to their competitors as they recognize deeper competition in the alliance portfolio.

Furthermore, two interaction terms, *Breadth × Technological status* and *Depth × Technological status*, are introduced to examine whether the focal firm's *technological status* relieves the negative effect of competitive embeddedness within its alliance portfolio network on the new alliance formation. First, the coefficient for *Breadth × Technological status* is positive and significant ($p<0.01$). This result implies that the higher the focal firm's technological status, the more it relieves the negative effect derived from the breadth of competition. As was previously discussed, the broad breadth of competition among partners within the alliance portfolio network leads to difficulty in new alliance formation due to the depletion of the focal firm's resources and anxiety of potential partners. Meanwhile, when the focal firm has a high technological status, the focal firm can enjoy fame in the technology market, and consequently does not need to devote enormous resources to search for a new partner. In addition, potential partners have no alternative but to form an alliance with the focal firm by taking the potential risk of technology spillover and coordinating the contract according to the risk. In other words, a high technological status in the technology market would lead to a high bargaining power. Second, *Depth* × *Technological status* also has a positive and significant ($p<0.01$) coefficient. High *Depth* of competition among partners causes conflict within the alliance portfolio network because of the incumbent partners' intervention against each another. In case of the high technological status of a focal firm, a variety of potential alternatives exist other than the current alliance relationship. From the viewpoint of incumbent partners, this scenario means that they lose control over the focal firm (Lavie, 2007).

Additionally, the coefficient for the control variable, *Manufacturing alliance,* which measures whether focal firm has experience for manufacturing alliance, shows a positive and significant value in both negative binomial regression and zero-inflated negative binomial regression. This result implies the specificity of biotechnology-pharmaceutical industry. The experience of focal firms (i.e., biotechnology firms') in manufacturing alliance with pharmaceutical firms signifies their success in technology development approved in at least FDI second round. Furthermore, the experience represents the focal firms' commercialization experience for their products in cooperation with pharmaceutical firms. Therefore, this experience indirectly provides a signal to potential partners of the focal firm's high level of technology development capability, and thus, attracts pharmaceutical firms in the alliance market. Table 6-4 shows the test results for the hypotheses mentioned earlier.

Table 6-4. Summary of the hypotheses

Hypotheses		Test results
H1-1	The deeper the competitive embeddedness among partners within the focal firm's alliance portfolio, the worse the focal firm's new alliance formation becomes.	Supported
H1-2	The broader the competitive embeddedness among partners within focal firm's alliance portfolio, the worse the focal firm's new alliance formation becomes.	Supported
H2-1	As the focal firm's technological status becomes higher, the negative effect that the depth of competitive embeddedness among partners has on the focal firm's new alliance formation is moderated.	Supported
H2-2	As the focal firm's technological status becomes higher, the negative effect that the breadth of competitive embeddedness among partners has on the focal firm's new alliance formation is moderated.	Supported

6.5. Discussion

The current study focuses on competitive embeddedness within the alliance portfolio. Moreover, the effect of competitive relations among alliance partners surrounding the focal firm on its future alliance formation is investigated. The research extends the concept of competitive embeddedness into the indirect area, and has an implication in that the influence of competitive relations among alliance partners within the alliance portfolio is examined. Nowadays, firms operate an alliance network and utilize network resources and the knowledge of partners to achieve innovation. Each partner within the focal firm's alliance portfolio network cooperates with the focal firm to pursue its own benefit. Especially, incumbent partners attempt to pursue private benefit other than common benefit, show opportunistic behavior, and consequently, do not participate actively in cooperation with the focal firm when exposed to competitive relations within the network (Khanna, Gulati and Nohria, 1998).

Another implication of the present research is the embodiment of competitive relations among partners by introducing the depth and the breadth concept. Previous literature measures competition among firms through the concept of niche overlap (Silverman and Baum, 2002; Gimeno, 2004). However, this method cannot include multi-dimensions of competitive relations. Therefore, the concept of breadth and depth derived from knowledge configuration and knowledge transfer is adopted (Cepeda and Vera, 2007).

Two key findings are presented in the current study. First, the greater the depth and breadth of competitive relations among alliance partners within the focal firm's alliance portfolio network, the more negative the focal firm's future alliance formation is. Second, in case of the focal firm's high technological status, the negative effect derived from competitive relations among partners decreases. Furthermore, three suggestions for effective management of competitive embeddedness within the alliance portfolio network are provided. First, focal firms should be concerned about the scope of business domains of potential partners in forming additional alliances. The breadth of competition among partners within the alliance portfolio network can expand through the focal firm's additional alliances. Second, to manage future alliance portfolio, focal firm should avoid a potential partner who competes with incumbent partners in the same business domains. Focal firm should recognize that higher depth of competition within its own alliance portfolio leads to difficulty in managing the whole network. Finally, the focal firm should prioritize technological status improvement to exercise high bargaining and controlling power against its current and potential partners. Only a limited number of powerful firms can implement the three suggestions mentioned earlier. Other firms may view controlling their partners' competitive relations as an exogenous area in practice. However, a high technological status can moderate the negative aspect of competitive embeddedness within the network. Thus, R&D activities, such as technology development and securing research manpower, can contribute to effectively managing alliance portfolio network. In particular, in case of hierarchical alliances between biotechnology-pharmaceutical firms, achieving technological status for focal firms is more essential.

Two findings of this dissertation can be found in the case of Google's Android. Google formed alliance network named Open Handset Alliance (OHA) by having varied mobile handset manufacturers, such as Samsung Electronics Company, Motorola, LG Electronics, HTC, involved in October 2007 to address Apple and achieve leadership in mobile OS market and finally released a mobile OS named Android. Unlike LG Electronics, which failed in managing competitive embeddedness within alliance network and lost incumbent partners, Google operated their alliance network effectively although some of their partners were highly competitive with each other. In the context of findings of this dissertation, the key points of Google's success are as followings. First, Google achieved leadership of Android camp by providing Android to their partners exclusively based on their technological status. In other words, high technological status of focal firm led to effective management of conflicts among partners. Second, achieved leadership made no barrier for attracting new partners such as Sony Ericsson, Pantech into their network without resistance of incumbent partners. It led to expanding line up of Android smart phone and growing alliance network of Android camp. Consequently, Android accounts for 61.0% of mobile OS market share as of 2012.

Competition and cooperation are the core of management strategy, and receive attention from many researchers. The term "competition" is also critical in an indirect area such as competitive relations among partners, the unit of analysis in the present research, as well as the direct competition between focal firm and partner. In the same context, the limitations of the current study and possible directions for future research are as follows. First, although the unit of analysis is alliance portfolio, the analysis is limited to the dyadic relations in the whole network to measure the competitive relations among partners. The concept of breadth and depth to measure competitive relations is introduced. However, multilateral competitive relations are not fully reflected because the said concept's way of measurement is constrained to dyadic relations. Thus, a new way of measurement that can reflect dyadic and multilateral competitive relations is hoped for in future research. Second, the selection of moderating variables is only constrained to technological status. The role of technological status is emphasized because the current research focuses on strategic technology alliance, and the dataset consists of focal firms and firms within their alliance portfolio, who mainly strive to develop technology to sustain their business. Nevertheless, several other factors, such as capability of managers, management capability for alliance portfolio network, and prior alliance experience, can relieve or strengthen competition among partners in the real business environment. It is also hoped that the role of other moderators will be unearthed in future research.

Chapter 7. Conclusive remarks

7.1. Summary and contributions

Technology alliances are widespread in current business landscape. In the face of growing competition and technological change, firms pursue a large number of technology alliances to access new resources, enter new markets or arenas, or minimize their technological risk. Whatever industry is involved, decision-makers in firms may endeavor to take advantage of technology alliances as a tool to improve the achievement of innovation. Ironically, however, a technology alliance is a sensitive project where different organizations cooperate to produce achievements. Thus, a series of reports warn the high failure rate of technology alliances.

This dissertation has the following three significances: First, the development process specialized in technology alliances aiming at knowledge acquisition and technology development is presented. A strategic alliance is a comprehensive concept that covers cooperation between various organizations such as JV, market alliance, equity-based alliance, and so forth. Certain studies including Das and Teng (2002) and Kale and Singh (2009) present the investigations on the alliance development process, but since they cover the comprehensive areas of strategic alliances, the guidance for successful alliances and progressive classification is also presented abstractly. This dissertation, therefore, aims to address such problems above by focusing on the technology alliance. Second, the model that covers the whole process of decision-making is simplified into the two stages: search and utilization. In addition, the practicality of specific stages is maximized in the order of the decision-making process and in the time sequence. Existing alliance process studies take the steps of partner selection and negotiating as the initial steps in their models with termination as the end of the process. Lastly, the technology alliances presented in this dissertation demonstrate major issues of each stage in order to enhance the persuasiveness of the guideline. I do not intend to underestimate existing studies, but the existing review papers that present the guideline for each step by integrating various previous studies on different subjects to be analyzed have the disadvantage of exceedingly simplifying corporate environments that are actually complicated. This study attempts to overcome the disadvantage of previous case studies by utilizing unified samples and empirical analysis specifically on the technology alliance.

The technology alliance development process presented in this dissertation is divided into two stages depending on the goal of decision-making. Specifically, it includes the search stage to address the use of technology alliances and selection of partners, and the utilization stage to come up with the way of utilizing and managing them after the decision-making. Further, there are four specific steps in the order of decision-making. Specifically, there are the “choice step” on how to utilize the technology alliance, the “partner selection step” to select partners, the “execution step” to come up with the appropriate way of utilizing the technology alliance, and the “management step” to manage alliance thereafter. Lastly, the technology alliance development process that connects the two purposeful processes and four lifecycle processes is presented. Refer to Figure 7-1 below.

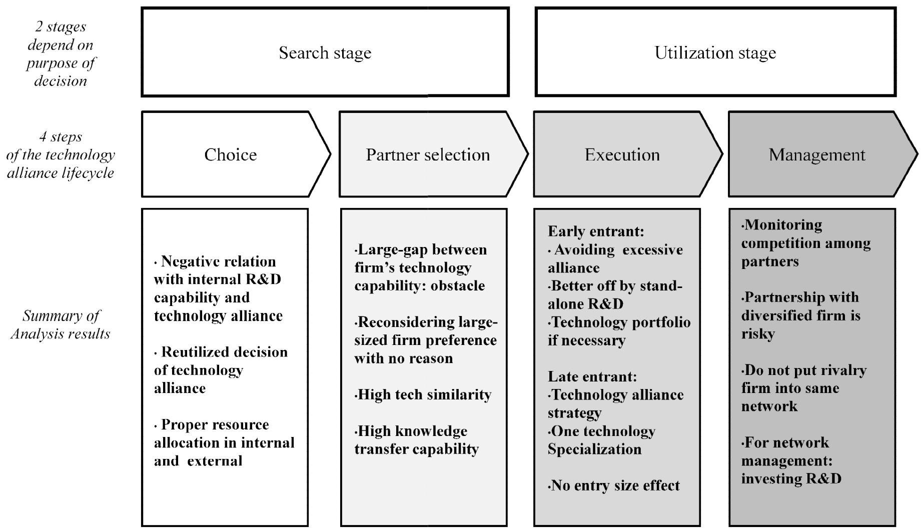

Figure 7-1. Summary of analysis results by development process

Chapters 3 and 4 include the study on the search stage of technology alliances. Chapter 3 investigates aspects to be taken note of in choosing technology alliance as the initial step of the technology alliance development process. The three basic contributions of this chapter are as follows: First, past experience, which is the proxy of organizational routine is classified into the three folds: accumulative-, recent-, diversified- experience in order for the systematic measurement of the organizational routine, which contributed to the theoretical expansion of the organizational routine. Second, this chapter finds that past alliance experience induces firms' new alliance formation. It also ascertains that prior alliance experience has a positive effect on the decision to choose a new alliance strategy. Therefore, managers have to judge carefully whether an alliance is reasonably chosen or not. Third, the negative relationship between alliance experience and internal R&D capability has been established. When firms choose an alliance strategy frequently, they can lose their long-term competency because of a worsened internal R&D capability. Therefore, firms still need to pay attention to and invest in internal R&D capability even when they ally with their partners with strategic needs.

Chapter 4 includes the study on how to find appropriate partners after it is decided to utilize technology alliances, which is the second step of the technology alliance development process presented in this dissertation. One of the features of the study on the partner selection step is that it specifies the structure of technology alliances as the relation between small/medium size businesses and large firms. 3 strategic implications can be derived from empirical results in Chapter 4. First, when small- and medium- sized IT firms find technology alliance partners, preferences for large-sized firms without a specific objective such as using partner manufacturing facilities should be reconsidered. Second, for the success of technology alliances, focal firms should look into 3 relational partner characteristics: (1) technology capability, (2) technology similarity, (3) capability for knowledge transfer in advance. Finally, large gaps between focal and partner firms' technology capabilities can be an obstacle for successful technology alliances.

Chapter 5 and Chapter 6 include the two studies related to the utilization stage of technology alliances. In Chapter 5, the development process corresponds to the third stage, and the specific ways of utilizing technology alliances in advancing into a new industry are addressed. The features of this study include the following two: First, the effects of technology alliances are classified and specifically presented in consideration of the business size and age of advancing into the market. Second, the photovoltaic industry, which is being highlighted recently, is analyzed in this chapter. This chapter suggests several implications for proper usage of technology alliance. Results suggest that entering the market earlier than competitors consistently works more beneficially for innovation performance than firms' initial size. Furthermore, empirical results reveal that, after market entrance, the technology alliance strategy of the firm is positively related to innovation performance. However, the positive effect of technology alliances is relatively diminished for early entrants. In contrast, the effect holds true for late entrants who require aggressive technology alliances. Additionally, building technology portfolio has a negative relationship on innovation performance, and such influence is more evident in late entrants.

As in Chapter 5, Chapter 6 is part of the utilization stage, and includes the study on the management step, the last part of the process. This chapter suggests that after the formation of a technology alliance, effective network management is the key element for the success of the technology alliance. As a result, the increase in the depth of competition and in the breadth of competition among partners within focal firm's alliance portfolio network indicates more difficulty in focal firm's new alliance formation. In addition, focal firm's high technological status relieves the negative influence of competitive relations among partners on focal firm.

7.2. Limitations and future research

In spite of the implications of this dissertation, some limitations could serve potentially as initiatives of future research.

First, this dissertation provides limited guidance to practitioners in that it is focused on filling out the gap between stages of technology alliance development process. Research on strategic alliance including technology alliance is rather mature and some studies suggest knowledge for implementing successful technology alliance for sure. But, it is rarely dealt with to be focused on sequential stages of technology alliance. Specific review papers on choice step or partner selection step would make huge contribution with fruitful contents on completing guidance for technology alliance in the future.

Second, the technology alliance development process presented in this dissertation does not include the steps of negotiating and termination. The reasons are as follows: as negotiation for cooperation between firms is of qualitative nature, and the case of alliance termination too has the difficulty of embodiment, this process is hard to converse it into an empirical study. Thus, this dissertation, which aims to present each step and involved empirical studies, had to leave out this area. As some scholars including Das and Teng (1997) and Brouthers et al. (1997), however, emphasize the necessity of the evaluation process after negotiation and termination of the relation, it may be still necessary to proceed with research on the process in such ways as survey, case study, and so forth.

Third, with regard to the “execution of technology alliance,” the utilization method of technology alliances is limited to ‘advancement into a new industry.’ Murray and Mahon (1993) specified that strategic alliances have 15 goals of utilization, and this dissertation summarize them especially regarding technology alliances into the three: (1) acquisition of knowledge and transfer of technology; (2) avoidance of technical, environmental, and financial risks; and (3) obtaining access to markets. Among the three goals above, this study focuses on (3) obtain access to markets, whose study has been insufficient, but this is merely part of the utilization method of technology alliances. (1) acquisition of knowledge and transfer of technology has been a popular topic in the traditional alliance research area (Gulati, 1998), and a lot of empirical studies have been implemented. Thus, it is necessary to collect and summarize studies specifically on technology alliances. Further, as to (2) avoidance of technical, environmental, and financial risks, some researchers including McGrath (1997) adopt and explore the concept of real option, but technology alliances are not the major focus. However, as global pharmaceutical firms tend to diversify their investment in various biotechnology firms to avoid risks, this method is made use of in practical affairs less than expected in the study. Thus, it is hoped that the study on technology alliances actively introduces the theory of real option to enrich the knowledge of the 'use of technology alliance' step.

Fourth, it is necessary to make up the development process for various types of collaboration such as JV and licensing in addition to technology alliances addressed in this dissertation. According to Kale and Singh (2009), Yoshino and Rangan (1995), and Leonard-Barton (1995), there are such a variety of forms of alliances. Although this dissertation mainly addresses technology alliances among various types of collaboration in order to maintain the focus of the study, it is evident that this type of business activity is not all available to achieve innovation. It is expected that various collaboration tools and development processes can be studied and compared for reasonable decision-making.

Finally, this dissertation is limited to the area of high technology or technology intensive industry. The best way to enhance the reliability in studies is to investigate all possible industries and control the extent of data by extracting the pure effects on a certain industry. For example, Cohen and Levinthal (1998) measured the effects of absorptive capacity in various industries to enhance the reliability of the concept of absorptive capacity. However, this is an exceptional case, and generally it is impossible to investigate every industry due to the limitation of data collection. Therefore, the researcher suggests the way of completing the technology alliance development process for each industry by means of the meta-analysis method.

It is hoped that if these limitations above are solved in future research, the comprehensive, practical manual for technology alliances will be created, and this will reduce the failure of technology alliances.

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국문초록

기술제휴는 유용하지만, 사용하기 어려운 전략적 도구다. 부족한 내부 자원을 외부로부터 조달하려는 다수의 기업들에게 기술제휴의 활용은 선택이 아니라 필수가 되었다. 그러나 최근 연구들에 의해 기술제휴는 예상외로 낮은 성공률을 보인다는 것을 지적 받고 있다. 수십 년간 많은 학자들에 의해 기술제휴라는 외부 소싱(external sourcing) 도구의 우수성은 검증되었지만, '기술제휴를 성공적으로 수행하기 위해 어떻게 활용해야 하는가?' 에 답을 주는 연구는 상대적으로 부족했다. 그 결과 실무진에 입장에서 기술제휴의 올바른 활용법을 제공하는 지침서가 만들어지지 못했고, 이는 기술제휴의 낮은 성공률로 이어 졌다.

본 논문은 상기 연구의 공백에 의한 문제를 해결하고 기술제휴의 효과적인 이용에 기여할 수 있는 연구를 수행한다. 구체적으로 다음의 두 가지 세부 목적을 가진다. 첫째, 기술제휴 수행 프로세스(technology alliance development process)를 탐색 단계(search stage)와 활용 단계(utilization stage) 중심으로 체계화하고, 기술제휴의 효과적인 활용에 기여한다. 둘째, 프로세스를 구성하는

각각의 단계별로 기존 연구에서 간과한 주요 연구 이슈를 제시하고, 이를 실증 분석함으로써 효과적인 기술제휴의 수행에 기여한다.

본문은 탐색 단계에 속하는 ‘choice step’, ‘partner selection step’과 활용 단계에 속하는 ‘execution step’, ‘management step’의 총 4 단계로 구성되어 있으며, 각 단계 별로 주요 이슈를 실증 분석한 연구들이 할당되어 있다. 덧붙여, ‘choice, partner selection, execution, and management step’의 세부 4 단계는 기술제휴 의사결정의 순서와 동일한 프로세스를 구성한다.

기술제휴 수행 프로세스의 처음인 ‘choice step’은 3장에서 다룬다. 본 장에서는 수행되는 연구는 다음의 두 가지 목적을 가진다. 먼저 기술제휴를 선택하는 의사결정과정에 있어서 과거의 경험에 의해 형성되는 조직적 루틴(organizational routine)이 미치는 영향을 파악한다. 둘째, 기술제휴의 사용이 조직의 내부 R&D 역량(internal R&D capability)에 미치는 영향을 탐구한다. 미국 나노바이오 산업 내 1,036 기술제휴 케이스를 분석한 결과, 기술제휴를 external sourcing 전략으로 활용한 경험이 많은 기업일수록 관성에 의한 제휴 전략의 선택이 많으며, 기술제휴 전략의 과도한 사용은 내부 R&D의 투자 소홀을 유도할 가능성이

높음을 경고한다.

이어 ‘partner selection step’은 4장에서 다룬다. 본 장의 연구는 상대적 파트너 특징이 제휴 성과에 미치는 영향을 분석함으로써 파트너를 탐색할 때 고려해야 할 3가지 요인들을 제안한다. 변수 설정을 위해 쌍대 관점(dyadic perspective)를 도입하여 파트너 특징을 중심 기업과의 관계를 고려했다. 분석을 위해 한국 증시에 상장되어 있는 IT 산업의 96개 기업의 276개 기술제휴 케이스를 수집했다. 분석 결과 다음의 두 가지 함의를 도출한다. 첫째, 파트너 기업의 기술적 역량이 높을수록, 기술적 유사성이 높을수록, 그리고 파트너 기업의 지식전달역량이 클수록 제휴 성공에 긍정적인 영향을 미친다. 따라서 상기 3가지 파트너 특성을 고려해 적합한 파트너 탐색을 행하기를 제안한다. 둘째, 일반적으로 파트너 기업의 자원 크기는 역전된 U-shape 형태로 긍정적인 영향을 준다. 따라서 기업 규모의 차이가 큰 중소-대기업 간의 기술 제휴는 성과 향상을 방해할 수 있음을 경고한다.

‘Execution step’은 5장에서 다룬다. 본 장에서는 기업이 외부 소싱 전략을 선택하고, 파트너를 탐색하는 탐색 단계 이후, 실제 기술제휴의 구체적인 활용법을 제안한다. 구체적으로 기업이 신사업

창출의 일환으로 신산업에 진입할 때, 기술제휴를 효과적으로 활용하기 위한 방법에 집중하여 연구한다. 이를 위해 먼저 신산업에 진출하는 기업의 진입 초기값의 차이에 따라서 혁신 성과에 어떠한 영향을 미치는 가를 가설화했다. 다음 시장 진입 이후 기술제휴의 사용이 상기 효과를 강화하는지 또는 약화시키는 지를 가설화했다. 분석을 위해 글로벌 PV 제조기업의 73 기술제휴 케이스를 수집해 여기에 특허 및 재무 데이터를 추가한 데이터셋을 구축한다. 음이항 회귀분석을 이용한 분석 결과 다음의 주요 세 가지 함의를 도출한다. 첫째, 시장 진입 시 기업의 크기보다는 경쟁사보다 빠르게 시장에 진입하는 것이 혁신 성과에 긍정적 기여를 한다. 둘째, 시장 진입 이후 협력 전략을 활용하는 것은 혁신 성과에 긍정적인 영향을 준다. 셋째, 협력 전략의 긍정적인 효과는 시장 진입 시점에 따라 다르게 나며, 선도 진입자와 비교해 후발 진입자의 경우가 협력 전략에 의한 긍정적 효과가 더욱 크게 나타남을 알 수 있다.

본 논문에서 제시하는 기술제휴 수행 프로세스의 마지막 단계인 'management step'은 6장에서 다룬다. 다양한 파트너 들과 계약을 맺고 있는 현대 기업들은 제휴 네트워크 속에 배태되어 있는 경쟁적 배태성(competitive embeddedness)의 관리를 요구 받는다.

경쟁적 배태성의 분석을 위해 바이오-제약 산업의 2539개의 기술제휴 케이스를 수집했으며, 이를 통해 159개의 제휴 포트폴리오 네트워크 데이터를 구축했다. 분석 결과, 제휴 네트워크 속에서 발생하는 경쟁적 배태성의 영향을 경쟁의 넓이와 경쟁의 깊이로 세분화하여 혁신 성과에 미치는 부정적 영향이 존재함을 밝혔다. 나아가 중심 기업의 입장에서 이를 체계적으로 관리하기 위해서는 기술적 지위의 확보에 힘써야 함을 제안한다.

본 논문은 다음의 3가지 의의를 가진다. 첫째, 지금까지 연구가 소홀했던 기술제휴 수행 프로세스를 제시함으로써 실무진에게 성공적인 기술제휴의 수행에 필요한 지침을 제공한다. 둘째, 탐색과 활용 단계에 속하는 4개의 세부 단계를 구축함으로써 명료함과 구체성을 동시에 확보했다. 끝으로 각 단계별로 충실한 실증 연구를 수행함으로써 기존 연구에서 케이스 및 소수 연구의 메타 분석을 통해 성공 요인을 제시하던 연구의 한계를 극복했다.

주제어: 기술제휴, 수행프로세스, 조직적루틴, 파트너특징, 진입초기값, 네트워크배태성

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감사의 글

졸업을 앞두고 지난 시간을 되돌아 보니 감회가 새롭습니다. 2005년 1학기 연구개발방법론 수업을 들으며 기술경영이라는 학문 분야가 있다는 것을 알게 되었고, 당시 수업에서 만난 기술경영 선배들과의 인연이 2006년 대학원 석사 과정에 입학하는 계기를 만들어 주었습니다. 입학 이후 졸업까지 진로와 관련해 많은 고민이 있었고, 중요한 고비마다 제게 힘이 되어주고, 학업을 계속할 수 있게 이끌어준 것은 다름아닌 제 주위의 소중한 사람들입니다. 이에 학위 논문의 마지막을 감사의 글로 마무리 합니다.

먼저 지도교수님이신 강진아 교수님께 감사의 말씀을 전하고 싶습니다. 석사, 박사 학위과정 동안 제가 달려갈 수 있게 격려와 믿음을 아낌없이 주셨습니다. 또 한 분의 은사이신 박용태 교수님께도 큰 감사를 전하고 싶습니다. 대학원에의 입학을 도와주셨으며, 재학 당시에는 생활을 관리해 주셨고, 졸업을 위해 심사위원장까지 맡아 주셨습니다. 졸업 논문의 개선에 큰 힘을 주신 김연배 교수님과 전략경영학회에서 뵙게 된 인연으로 논문 심사위원까지 맡아주신 연세대학교의 박경민 교수님께도 감사를

드립니다. 그리고 대학원의 큰누나이자, 창호 선배의 부인이기도 하며, 학위 논문 심사위원이기도 한 노현정 교수님께도 큰 감사를 전합니다.

소중한 가족들에게도 감사의 마음을 전하고 싶습니다. 사랑이 많으신 저의 아버지, 힘이 들 때면 항상 먼저 전화를 주시는 저의 어머니, 동생을 위해 언제나 헌신적인 형님에게 감사와 사랑의 마음을 전합니다. 그리고 또 한 명이 있습니다. 대학원 입학 이후 첫 학기 수업에서 우연히 만났고, 6년이 넘는 시간 동안 한결같이 제 옆을 지켜준 여자친구 민경이에게 글로 표현할 수 없는 사랑을 전하고 싶습니다. 더불어 민경이에게 받은 사랑은 최소 2배 이상으로 돌려줄 것을 약속합니다.

제게는 두 개의 연구실이 있습니다. 기술경영 연구실과 강진아 교수님 연구팀의 후배들에게도 감사의 말을 전합니다. 대학원에서 저와 가장 많은 시간을 함께한 기현이, 새벽을 함께한 우석형, 귀석형, 혁준형, 저를 연구실에 두고 먼저 졸업을 하신 장혁형과 정훈형, 그리고 형들의 거친 애정을 중화시켜 주신 소중한 누나 3인방 현정누나, 유진누나, 효정누나에게도 엄청난 감사의 마음을 전합니다. 연구팀의 미래를 담당하고 있는 진환이, 민선이, 길수는

든든하고 고마운 후배들입니다. 이들에게도 특별한 애정과 감사를 혼합해서 전하고 싶습니다.

글을 작성하면서 소중한 사람들을 떠올려 봤습니다. 너무나 많은 사람들에게 도움을 받으며 대학원 생활을 하고 있었고, 이들의 도움이 있었기에 박사 학위를 받게 되었다는 것을 알게 되었습니다. 이들 모두에게 감사의 마음을 다시금 전하며 글을 마치겠습니다.